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Operational scalability of a system

An action plan towards a more streamlined system

Helsinki Metropolia University of Applied Sciences

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I would have written a shorter Thesis, but I did not have the time.

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The objective of this study was to define the current operational scalability of a digital advertising system developed by a company that will not be named, while pinpointing the main challenges (themes) that need to be solved in order to improve the situation. This is important because the system needs to become more scalable in order to be used in large scale operations all around the world on a routine basis, by both new and less experienced system operators alike.

In this study, “operational scalability” of the system is defined as the usability, training difficulty, operational risk, and preferred development prioritization of each task in the operational workflow, that the system operators need to perform during each event where the system is being used at.

The current state analysis was based on both quantitative (ratings) and qualitative (comments) data gathered from a questionnaire study on the operational scalability of the current system and its operational workflow. The questionnaire was presented to both company system operators and developers, with the operators responses highlighted while both views were analysed and compared. The most important findings from this current state analysis were that overall the operational scalability of the system is surprisingly good and developers are more critical towards the system than the operators, but there are still many individual operational tasks where this is not the case and scalability should be improved.

The theoretical framework was built on the identified key challenges for operational scalability, i.e. the themes identified in the current state analysis. These “best practises” were derived from literary analysis of academic papers about ensuring end-user satisfaction in system development, improving communication, and arranging efficient training programs.

The outcome of this study culminates in an Action Plan, where both concrete ideas and more general strategies - either directly from, or inspired by - the questionnaire data analysis and the theoretical framework, were synthesized together into a coherent plan for improving operational scalability of the system.

Keywords	SW HW system development, end-user satisfaction, operational scalability, usability, training, communication, TV broadcasting,

Contents

Common abbreviations

SW = software

HW = hardware

UI = software user interface

OB = outside broadcast van

OPS = operational department

R&D = research and development department

QA = quality assurance department

CMC = computer-mediated communication

SME = subject matter expert

CTA = cognitive task analysis

1 Introduction

In this first chapter, the company (that will not be named) and its digital advertising technology (from here on referred to as “the system” or “technology”) are first briefly introduced, after which the business (research) problem is presented and expected findings and intended outcome will be summarized.

1.1 Background

The company operates in sports media and technology, whose system is revolutionizing perimeter advertising in televised sports. The system replaces traditional perimeter advertising billboards in sports broadcasts with digital (virtual) advertising content in the TV feed. While the audience on the venue sees the local, printed advertisements on the pitch-side billboards, television viewers across the world see a digital billboard with advertisements relevant to them and their region. Digital advertisement can be geographically tailored and what would normally be a single physical advertisement space can now be resold exponentially depending on the different regions the event is being broadcasted to.

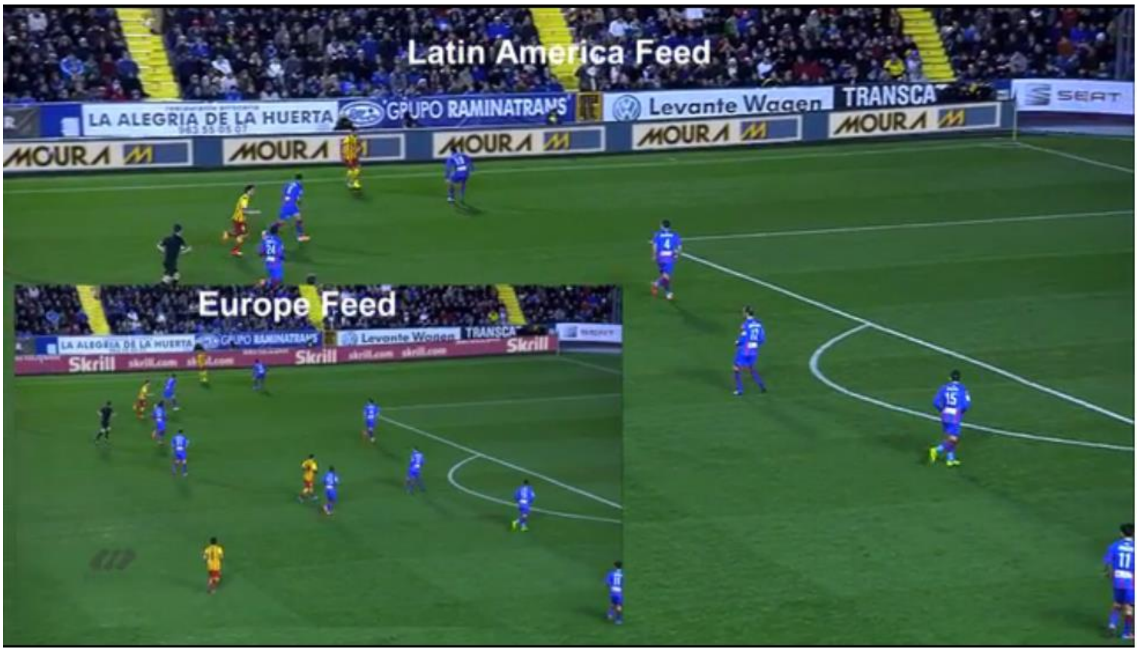

Figure 1. The system replaces the physical billboard with digital advertising that is tailor-made for different geographical regions (example from Levante vs. FC Barcelona 19.1.2014)

This technology is useful for both national and global advertisers and brands. International brands can approach their advertising on a region-specific basis, selecting the most relevant and effective languages, graphics and media to target each consumer group, while national brands that are unable to justify spending on global advertisements can gain valuable national exposure at some of the world's biggest sporting events. In addition, the technology enables the use of controversial advertisements that may be banned at the host country where the event is being held (betting, tobacco, alcohol, etc.), as it can be used in feeds being broadcast to regions where this kind of advertisement is sanctioned.

The company's operational crew works at events, which take place on a weekly basis, mainly in Europe, but increasingly also in other parts of the world.

The technology is a combination of software (SW) and hardware (HW) components. Operational development takes place in London, while SW and HW development takes place in Finland.

The author of this Thesis has worked for the operational department of the company for over 5 years as both operator and operational developer, first as a *System Specialist*, then as an *Operations Manager,* and currently as a *Technical Production Manager*.

1.2 Business problem

Since the company holds a monopoly in digital billboard replacement technology, there is an increasing need to do more events all around the world with only a handful of experienced senior system operators to run the system. In order to meet this demand, the company needs to train new operators fairly quickly, but this is difficult as the system is fairly complicated, and difficult to train and to operate since it is still under development.

Setting up and operating the system at each event involves a fairly complicated HW setup followed by even more complicated and sensitive calibrations on both HW and SW levels. The calibrated system is also adjusted frequently during the live broadcast. Sometimes a thorough calibration may not be sufficient for good quality, because system operators may run into problems that have not been faced, predicted or communicated before, and either the crew or the system might not be ready for tackling these issues properly, which is also one reason why the system is still under constant development.

This is why achieving and maintaining acceptable calibration quality, quickly solving known or new problems, and adapting to the changing live broadcast conditions in real time requires in-depth knowledge and experience on the technology from the senior operator. Current senior operators have reached their level of expertise through years of operating the system in a live broadcast environment, thus it is difficult to “train” more senior operators within an acceptable time frame.

Training new senior operators is important because in order for the company to be profitable it needs to deliver successful events all around the world and in a routine manner. However, current system complications and limitations combined with an inexperienced crew may lead to unsuccessful events. Failing to deliver at events is costly not only financially, but also detrimental to customer, partner and broadcaster relationships and the overall future of the company.

Therefore, the company needs to focus system development efforts towards making the system and the overall workflow more streamlined, which in practice means robust to work with and easy to train new operators on. Ultimately, it should be easier for new operators to first learn in a safe environment and then manage independently and in a routine manner at real events without acquiring years of in-depth experience on the system. At the moment this is difficult until the operational scalability of the system is enhanced in terms of improving system usability and training difficulty, while reducing problems encountered and caused by the inherently complicated system or inefficient operational workflow.

1.3 Objective and intended outcome

The objective of the study is to help push the product from the lab towards the field by identifying and evaluating the key challenges related to the operational scalability of the system.

This is done by identifying which elements in the current system are perceived as difficult to learn, operate, or otherwise seen as operationally risky and in need of further development. This analysis is done from an operator -and developer point of view while concentrating on the first mentioned, and recognizing what kind of development would need to be prioritized, and how operator and developer views differ from each other.

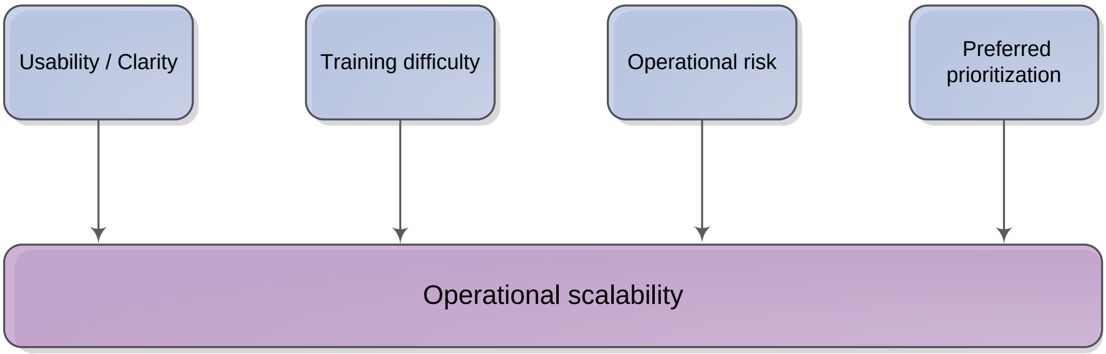

Figure 2. Different aspects of operational scalability for the system and workflow

In order to achieve this, a full breakdown of the current operational workflow will be performed, based on which, tailored questionnaires will be generated and presented to operators and (operational and R&D) developers. These questionnaires are expected to produce ample amounts of data on operational tasks in terms of operational scalability.

This study is expected to produce the following findings that should help develop the technology and operational workflow towards a more operationally streamlined system:

- Operator and developer team ratings and comments for each aspect of operational scalability on each operational task in the workflow
  - Usability/clarity
  - Training difficulty
  - Operational risk
  - Preferred development prioritization
- Identifying key challenges (themes) in the operational workflow in terms of operational scalability through a detailed task analysis on the ratings and comments
- Comparison between operator and developer views. This should indicate how well operator expectations, i.e. end-user satisfaction, is met with current system development
- New ideas, strategies and methods to improve operational scalability

- Breaking down operational workflow into a list of specific and categorized tasks, providing a clear overview on the current operational workflow. This can also be used for training purposes.
- In the future, the questionnaire template could be used as a tool for monitoring progress of new operators being trained
- This study can be reproduced annually to monitor how development meets operator expectations

In other words, this study may serve as a reproducible, combined and analyzed information package, which may help on the management and decision making level when it comes to planning and prioritizing current system development towards increased operational scalability.

2 Methods and material

In this section, the research process is briefly explained followed by a more detailed description about the data collection and analysis methods.

2.1 Research Process overview

In this chapter the research process is discussed; see Appendix 1 for a simple block diagram of the research process.

Identify the business problem

The whole process begins with identifying the business problem, which is essentially that the system and workflow lacks operational scalability. The system is complicated and not very robust, which makes it difficult for inexperienced operators to quickly learn and operate in a routine manner.

This kind of inherent complexity is natural for emerging, first mover technologies such as this system. The technology is still at a point where it remains under constant development and rapid change, which is necessary for the technology to ultimately progress to a certain level required of it. The downside is that every new development tends to add to the overall complexity of the system and there is generally a lot less time and resources available for usability improvements. This is why it is important to find out what the key challenges are for operational scalability of the system in terms of usability, learning difficulty and operational risk, and hopefully to concentrate improving the situation on these most critical areas of the system, while preferred development prioritization should also be taken into account, both from the end-user and developer perspective.

It is also important to find out if there are any differences of opinion in where the operators and the developers see the key challenges at. This way, should the management choose to spend more development resources on improving usability, they can ensure that the developers are concentrating on where it really matters from the end-users point of view.

Define the operational workflow – breakdown into a list of specific operational tasks
Based on the author's extensive experience on developing and working with the system, the operational workflow is broken down into **73** specific operational tasks (see Appendix 2). This is essentially a list of tasks that an operator team is involved with leading to and during an event.

Each task is categorized based on the department responsible for developing them: "Operational", "R&D" or "both". For example, some tasks like the event call sheet (pre-event information package) are strictly "operational", whereas practically all SW related tasks fall under "R&D" responsibility, but on many tasks the development responsibility is shared by "both" departments.

Table 1. Task development distribution

The developing department	Tasks
Operations	20
R&D	38
Both	15
Total tasks	**73**

Development responsibility over different tasks is distributed between departments as shown in table 1 and figure 3.

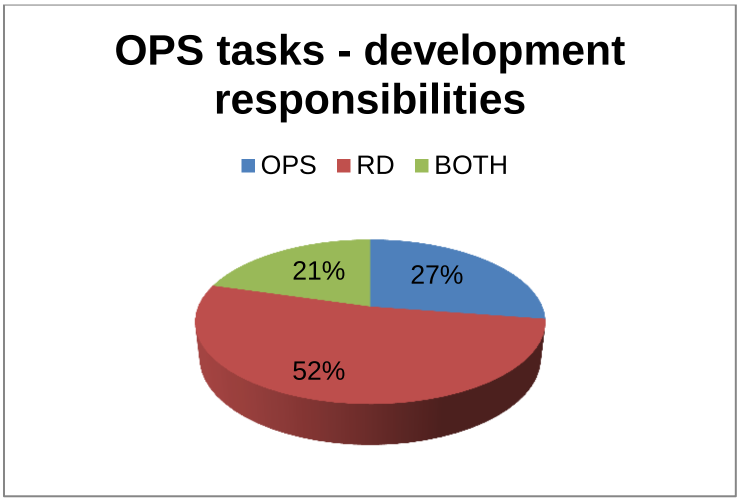

Figure 3. Task development distribution

Because the company is still very much an R&D company, the majority of the tasks falls under R&D responsibility as illustrated in the pie chart above.

Generate and present tailored questionnaires for the three stakeholders

The questionnaire structure is based on the 73 operational tasks, each of which will have three to four questions on operational scalability. There will be three different questionnaires targeted at operators, operational developers and R&D personnel. Operators are expected to answer all questions with the exception of one outsourced operator who is much less experienced and is not expected to answer questions on all tasks. The developers are expected to answer only to tasks that they are personally involved in developing.

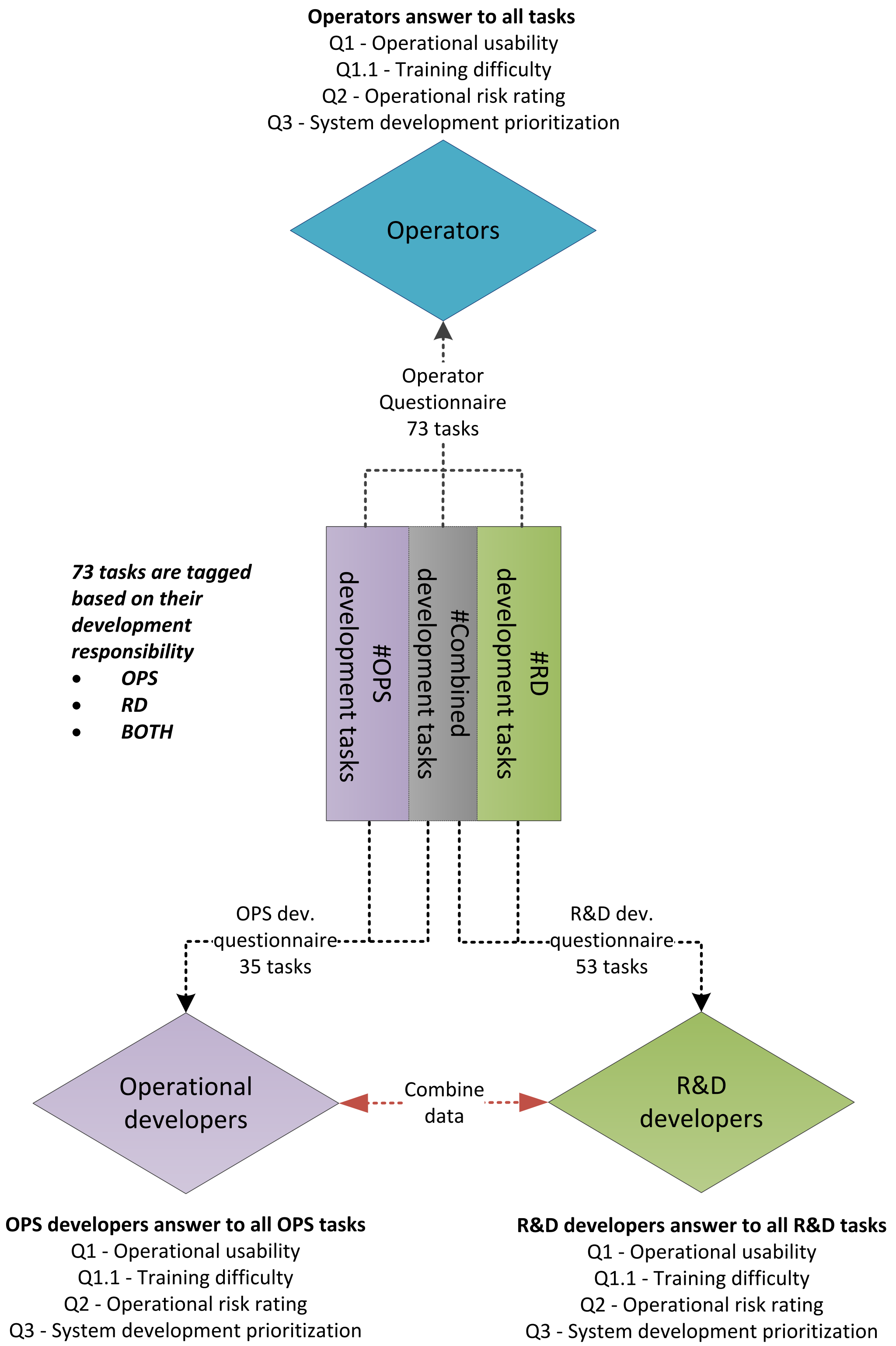

Figure 4. Questionnaire structure based on the task development distribution

The operator questionnaire will be presented to all operators (including one outsourced operator). Because the operators are involved with each operational task their questionnaire has questions on all 73 tasks.

The *operational developer* questionnaire will be presented to all operational developers, i.e. operational management who are responsible for developing tasks that are strictly operational (OPS) and tasks that require both operational and R&D development (BOTH). This questionnaire has questions on 35 tasks.

The *R&D developer* questionnaire will be presented to all R&D developers, i.e. R&D management and key developers who are responsible for developing tasks that are strictly R&D and tasks that require both operational and R&D development (BOTH). This questionnaire has questions on 53 tasks.

After the data collection phase, the operational -and R&D developer data (ratings and comments) are combined into one and treated as combined “developer” ratings and comments.

Current state analysis

Detailed analysis for each task will be performed based on operator and (combined) developer ratings and comments, which will also be compared. Key challenges (themes) for operational scalability will be identified and discussed in the current state analysis.

Best practises – literary analysis

This section is about incorporating existing research into a theoretical framework for improving operational scalability. The literary areas of interest are defined by the re-occurring themes identified in the current state analysis.

Proposed action plan to improve operational scalability

Based on the current state analysis and theoretical framework, an action plan will be formulated where ideas, methods and strategies are presented to improve operational scalability related to the identified themes.

Feedback on proposed action plan

The proposed Action plan is presented to operational and R&D management and key developers for feedback in this last section.

2.2 Data collection and analysis methods

Data is collected from questionnaires that are presented in the form of an Excel spread sheet, where each operational task will have 3-4 questions and a comments section. The data will consist of numeric ratings and comments for each task on usability, training difficulty, perceived operational risk, and preferred development prioritization.

Detailed task analysis is performed for all tasks, which will be amended as Appendix 6. Average operator and developer ratings are calculated for usability, training difficulty, operational risk and preferred development prioritization. Finally, differences between operator and developer ratings and comments are analyzed and re-occurring themes hindering operational scalability identified.

2.2.1 Questionnaires

As mentioned before, three questionnaires are formulated, one full questionnaire on all (73) tasks for the operators, and two downscaled versions for operational and R&D developers based on the task development responsibility.

Operator questionnaire

Operator questionnaire will have questions on all 73 operational tasks. Each task will have either three (Q1, Q2, Q3) or four (Q1, Q1.1, Q2, Q3) questions.

Table 2. Operator questionnaire – example question about one task

Q3: Future prioritization starting from today. Don't give them all a "5". Give higher ratings only to tasks that you feel really need to be improved			
Task X	**Info about task**	**Year ago**	**Now**
Q1	*How easy for operator to perform in a routine manner within acceptable time frame?*		
Comments:		(1= clear/easy --- 5= very unclear/difficult)	
Q1.1	*How easy for a new operator to learn and fully understand?*		
Comments:		(1= clear/easy --- 5= very unclear/difficult)	
Q2	*How often do you think we have problems with this?*		
Comments:		(1= never --- 5=always)	
Q3	*Rank the importance of making this clearer/easier (for the future, starting now)*		
Comments:		(1= unimportant --- 5=very important)	

Above is an example on *Task X* that has 4 questions, where the yellow cells are to be filled in by the subject. Depending on the given rating, which is always between 1-5 (good – bad), the yellow cells turn into different shades of red when filled in, this helps the subject to better visualize his ratings as he is filling them in.

Table 3. Operator questionnaire – filled in example question about one task

Q3: Future prioritization starting from today. Don't give them all a "5". Give higher ratings only to tasks that you feel really need to be improved			
Task X	**Info about task**	**Year ago**	**Now**
Q1	*How easy for operator to perform in a routine manner within acceptable time frame?*	3	2
Comments:	Task has improved, but we sometimes struggle with this because...	(1= clear/easy --- 5= very unclear/difficult)	
Q1.1	*How easy for a new operator to learn and fully understand?*	1	1
Comments:	This should be fairly easy to learn	(1= clear/easy --- 5= very unclear/difficult)	
Q2	*How often do you think we have problems with this?*	3	2
Comments:	There are still problems with this occationally, for example...	(1= never --- 5=always)	
Q3	*Rank the importance of making this clearer/easier (for the future, starting now)*	4	
Comments:	This should be made easier as it is quite an important task and we sometimes have problems with it	(1= unimportant --- 5=very important)	

Questions “Q1, Q1.1 and Q2” will always have a past (“year ago”) and current (“now”) rating. This research project concentrates on the current situation, so the past rating is there only to help the subject put things into perspective and help the subject better evaluate the current situation.

The first question “Q1” is about the operational usability and clarity of a given task. This is where the subject needs to think about usability and clarity of each task. It should also be noted here that on some tasks this question is phrased a bit differently as “How clear?” a given task is for the operator.

On some tasks there is also a sub-question “Q1.1”, which is about the estimated training and learning difficulty of a given task for a new operator. This is the only question that does not appear on all tasks and the reason for this is that some tasks (event call sheets, event communication etc.) are not really “taught” and do not require separate training.

The second question “Q2” is about the perceived operational risk, i.e. how often the subject feels that the operator team encounters problems with the task in question.

The final question “Q3” is about preferred development prioritization. It indicates the subject’s personal opinion on how much each task should be prioritized in the development pipeline. Naturally, everything could always be improved, but while time and resources are limited in the real world, subjects are instructed not to give every task a high rating, but to be realistic and conservative in their prioritization rating.

Each question has a comments section and subjects are encouraged to provide details and examples that explain and provide more insight on their ratings.

Developer questionnaire

The *operational* -and *R&D developer* questionnaires are essentially the same format as the operator questionnaire and with the same questions, but, as discussed earlier, developers have fewer tasks they have to answer to. Still, all 73 tasks will be answered to by some developers, whether it is operational or R&D developers or sometimes both if they are jointly responsible for development of a given task.

Table 4. Developer questionnaire – example question about one task

Answer only tasks you or your team have been developing *Q1, Q1.1 and Q2: "Year ago" & "Now" based on something developed. "Year from now" based on something either in development or in planning* *Q3: Future prioritization starting from today. Don't give them all a "5". Give higher ratings only to tasks that you feel really need to be improved*				
Task X	**Info about task**	**Year ago**	**Now**	**Year from now**
Q1	*How easy for operator to perform in a routine manner within acceptable time frame?*			
Comments:		(1= clear/easy --- 5= very unclear/difficult)		
Q1.1	*How easy for a new operator to learn and fully understand?*			
Comments:		(1= clear/easy --- 5= very unclear/difficult)		
Q2	*How often do you think we have problems with this?*			
Comments:		(1= never --- 5=always)		
Q3	*Rank the importance of making this clearer/easier (for the future, starting now)*			
Comments:		(1= unimportant --- 5=very important)		

One small difference to the "operator questionnaire" is that on two questions (Q1 and Q1.1) developers can also estimate future improvement (year from now) based on something they are developing or planning. Like with the past ratings, the future ratings are not analysed in this study as they are only meant to help provide the developer a frame of reference when rating the current status of the system.

Operator questionnaire - subjects

Below, each person taking the operator survey is briefly introduced. Justification for why they were selected to take part in the survey is also given.

- One 1st generation operator
  - Senior operator / Operations Manager
  - 4 years of experience on operating the system
  - Very experienced operator who has also been somewhat directly involved with system development.
- Two 2nd generation operators

  - Operators
  - 2,5 years of experience on operating the system
  - Indirectly and occasionally involved with system development through system testing and operator feedback
- Three – 3rd generation operators
  - Junior operators
  - 1,5 years of experience on operating the system
  - Indirectly and occasionally involved with system development through system testing and operator feedback
- One outsourced operator
  - Trainee operator
  - Sporadic experience on operating the system over 2 years, more experienced on HW rigging than SW operation
  - Not involved with system development
  - Due to limited experience, not expected to answer questions about all tasks

Developer questionnaire - subjects

Below, each person taking the developer survey is briefly introduced.

Operational developers

- Head of operations
  - Operations senior management
  - 3.5 years of experience on managing the operations department
- Senior Operations Manager
  - Operations senior management
  - Senior Operations Manager
  - 2 years of experience on managing the operations team
- Production Manager
  - Operations middle management
  - 2.5 years of experience on managing productions
  - Due to limited on site experience, not expected to answer questions about too many tasks
- First Unit Manager
  - Operations middle management
  - 2.5 years of experience as a Unit Manager

- Second Unit Manager
    - Operations middle management
    - 1 year experience as a Unit Manager

R&D developers

- Chief Technological Officer (CTO)
    - R&D senior management
    - 6 years of experience on managing the R&D department and development strategy
- R&D Manager
    - R&D middle management
    - 2.5 years of experience on managing R&D teams and development
- Technical Product Manager
    - R&D middle management
    - 5 years of experience on managing technical product development and QA
- QA Manager
    - R&D middle management
    - 1 year of experience on QA and a few months of experience on managing the QA team
- R&D senior developer and systems architect
    - 6 years of experience on developing the system
- R&D senior developer
    - 4 years of experience on developing the system
- R&D senior developer
    - 6 years of experience on developing the system
- R&D senior developer
    - 2.5 years of experience on developing the system
- R&D senior developer
    - 2.5 years of experience on developing the system

2.2.1 Expected data

The 3-4 questions about each task on the questionnaires are expected to produce average operator and (combined) developer ratings data and comments for:

- **Q1 Current usability / clarity**
- **Q1.1 Current training difficulty**
- **Q2 Current operational risk**
- **Q3 Current preferred development prioritization**

In addition to numeric ratings, questionnaires are also expected to have a lot of comments, which should help further analyze and explain the underlying reasons behind the given ratings. The subjects are expected to provide examples on specific things that have been improved, should be improved, and even ideas on how to improve them. The operator perspective represents the end-user expertise on the operating conditions and overall system knowledge, while the developer perspective is grounded, and perhaps somewhat limited to, expertise about specific areas in system development.

Eventually, ratings between operators and developers will be analyzed and compared in order to find out the differences between end-user and developer views for each task and aspect (question) of operational scalability. All in all, analyzing these ratings and comments should make it fairly straightforward to identify the key challenges, i.e. re-occurring “themes”, that seem to affect operational scalability based on which an action plan for system development can be formulated.

3 Current state analysis

In this chapter, current company development and system workflow is first briefly explained, after which the results from the questionnaire data analysis are summarized and re-occurring themes affecting operational scalability are presented.

3.1 System development workflow

Before analysing the questionnaire data and comparing the results between operators and developers, it is important to first understand how the system is currently being developed by both operational -and R&D departments.

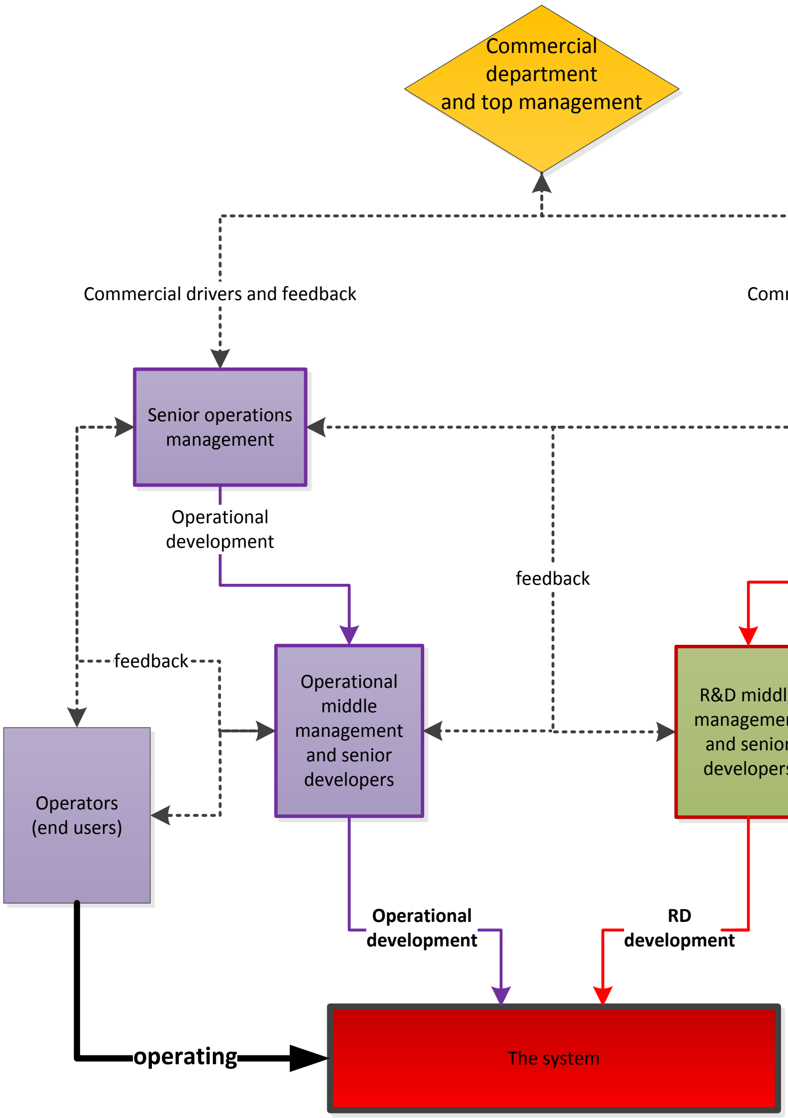

Figure 5. Current development workflow

Like in practically every other company, the underlying commercial forces are the driving force behind all product development. Ultimately, the top management makes the high level decisions on development strategy based on commercial factors, but since this research project concentrates on a single commercially recognized business problem, i.e. operational scalability of the system, other commercial forces behind product development will not be discussed or analysed here.

The second ladder in this development workflow is the departmental management that answers directly to the top management. Their job is to manage and plan the high level development strategies in co-operation with the commercial department, and to manage their departments and the actual development.

Senior operations management is responsible for managing the operational department and developing operational processes. Since most system development falls under the R&D department, they also communicate high level operational development requirements to R&D senior management, which in turn is deeply involved with all development aspects while managing the R&D department in line with commercial expectations.

Operational middle management is deeply involved with every aspect of operational development, and there is tight co-operation between operational -and R&D middle management that in turn is in charge of different aspects of R&D system development and the individual developers and teams.

Finally, there are the operators who actually operate the system at the field and provide the end-user feedback through operational middle management. Operators are not aware of the individual R&D developer responsibilities, and consequently many R&D developers do not possess an in depth understanding on the system as whole, let alone how it all works at operational field conditions.

The development workflow is not strictly isolated, but there is still a fair degree of compartmentalization. Most of it is absolutely necessary in order to manage development efficiently, but the obvious downside to this is that the company runs the risk of those making development decisions not being fully aware of the preferred operator development requirements, while developers may not fully understand the impact of their development decisions on the end-users of the system.

Furthermore, because most development, both operational and R&D, is heavily overlapping, if key developers fail to understand the big picture on how the system works in practice, it can be potentially detrimental to combined system development as developer creativity diminishes. There may be less ideas and innovative approaches if developers have been strictly compartmentalized to work on a single or few parts of the system. Also, allocating development resources, i.e. development prioritization, is always a bit of a balancing act, especially if end-user preferences are not clear to all stakeholders.

Consequently, this research project is expected to indicate development requirements from the end-user (operator) perspective, and to analyse how well those requirements are understood and taken into consideration in current system development.

3.2 The system – brief technical overview

This chapter is about presenting a general and fairly simplified overview on how the technology works without going into too much detail.

Modifying feeds

The system is integrated with the live TV program production. In practise this means that the company has an outside broadcast van or an “OB” that is connected to the main host broadcaster OB.

The system takes in the TV program feed produced by the host broadcaster and “modifies” it by rendering the digital advertisement on top of the physical billboard when it is seen in the live TV program. In other words, the physical billboard is replaced by the digital billboard in the TV picture and seen by TV viewers around the world, while the audience at the stadium will still see the original, physical billboard.

The is able to produce many modified feeds with different digital advertisements from a single TV program feed. In theory, the number of modified feeds is limited only by the satellite bandwidth available. Here lays the core business model for technology; each modified feed has tailored, targeted advertisements for different geographical regions so that the traditional single physical advertisement space can now be sold multiple times.

The system is housed in an outside broadcast van

The company has its own outside broadcast van or “OB”, which is integrated together with the host -and other broadcast OBs involved in the production, where the system is essentially an add-on “graphics” van.

The company’s OB houses various broadcast HWs and a monitoring area for operators, but the core components are a number of powerful PCs that run the various SW components that are responsible for tracking, masking and eventually modifying the TV program feed(s) with the digital advertisement.

These SW components can be roughly divided into two groups, primary SW responsible for “tracking” and “masking”, and secondary SW responsible for signal routing and rendering the digital advertisement.

Cameras

Generally only two cameras, the main and close-up, are used by the system. This means that the digital advertisement is rendered over the physical billboard only when one these two cameras appears on the live TV program and the billboard is visible in the camera shot. In most sports, these two cameras have about 95 % of the total billboard coverage during the live match, so at the moment there is no commercial incentive to integrate the system with more cameras.

The TV camera is placed in a special camera bracket provided by the company to integrate the camera with certain specialized HW components that are also placed into this bracket.

Tracking the physical billboard

In order to replace the physical board with a digital billboard, the system must always know where the billboard is in the TV picture. This process is referred to as “tracking” the billboard and it is done in real time. Tracking needs to be very accurate, otherwise the digital board rendered on the TV picture might not perfectly overlap and cover the original board.

Masking objects that appear in front of the billboard

While the billboard is being tracked in real time, the system also needs to make sure the digital ads are rendered only on the physical billboard and not on any objects appearing in front of the board. This process of separating the background billboard from any foreign objects (players, balls, goal net etc.) appearing in the foreground is referred to as “masking”, which is a unique and important feature of technology.

3.3 Operational workflow

As discussed before, the operational workflow involved with each production was first broken down into 73 specific tasks that operators need to perform (or are involved with) during the event. This was done in order to form the questionnaires and gather task specific data on operational scalability.

However, in this section, where the data analysis and findings are summarized for the reader, the operational workflow is simplified by categorizing the tasks into 9 chronological production phases (figure 6). This is done because the reader is not expected to understand the underlying intricacies behind each task as that would require fairly in depth understanding on how the technology works. If the reader is interested on the individual tasks, he may refer to Appendix 6 where each task is explained and then analysed in detail.

Furthermore, this study is not really about finding concrete solutions for specific tasks, although some will surely emerge from the final output and action plan, but it is more about gathering a strong overview on the current operational scalability of the system as a whole, while pinpointing weak points and identifying re-occurring and underlying themes that seem to affect operational scalability of several tasks.

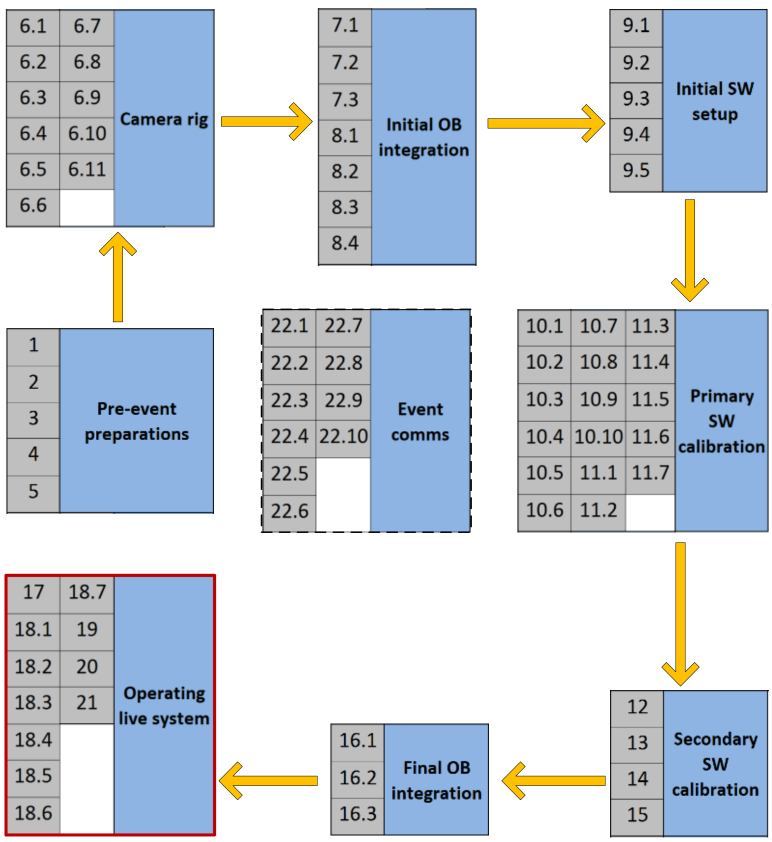

Figure 6. Operational workflow and tasks

Phase 1 - Pre-event preparations

This first phase involves event planning and internal or external pre-event communication, including for example crew assignments and travel arrangements. Unlike in the following phases, in this first phase operators do not actually have much control over the actual tasks, as they are often the target of these tasks or otherwise indirectly affected by them as different people (operational management) are responsible for pre-event planning and communication. Therefore, when operators rate tasks about this phase, it is really more about how efficiently or well these tasks have been handled for them, and are they experiencing problems because some tasks are not well handled.

Phase 2 - Camera rig

This is the first phase that operators are directly involved with, and it takes place during what is called “rig day”, which precedes the day the event is being held. This phase is about setting up or “rigging” the broadcast cameras and integrating them with HW components of the system.

In practise this involves erecting a tripod and camera while attaching the special camera HW on it. With a normal TV camera this process is fairly straightforward, but with the system it takes more time and is much more complicated as it involves additional mechanical installations, cabling, and finally approval confirmation from the host broadcaster.

Phase 3 - Initial OB integration

During this phase operators need to integrate company -and the host broadcast OB vans. This process involves making the required connections between the two OBs and setting up HW at the company’s OB.

Phase 4 - Initial SW setup

This phase is about preparing all the SW components to be run on designated system PCs.

Phase 5 - Primary SW calibration

This phase is about calibrating and fine tuning the main SW components. This phase is expected to take the most time at each event, as the main SW components are the most important part of the system, while they are also the most sensitive and least automated.

Phase 6 - Secondary SW calibration

The second and last calibration step is setting up the secondary SW components. These components are fairly automated and quick to setup.

Phase 7 - Final OB integration

After the system has been calibrated, last checks need to be performed with the host OB to confirm that everything works as it should, and the system output signal(s) meet broadcast quality requirements.

Phase 8 - Operating live system

Operating the live system involves monitoring primary and secondary SW and making adjustments in order to maintain the final output signal quality, which operators need to assess, and bypass the system accordingly if the quality is unacceptable and they are unable to fix it in real time.

Consequently, this is the most stressful and difficult phase for the operators as it is very difficult to monitor and adjust several settings at the same time, while the system output feed is constantly being broadcast live on air unless the operator chooses to bypass it, which should always be a last resort due to commercial reasons.

Phase 9 - Event communication

This is not really a chronological phase as it affects all phases. It is about the teamwork and communication between the crew on site and the offsite remote support. It is also tied to working and communication with the host broadcaster. Finally, it is also about the quality of the post-event reports generated by the operators.

3.4 Current state summary

In this section, data analysis workflow is explained and the findings are summarized. The workflow is divided into 3 separate stages; see Appendix 3 for a diagram illustrating the data analysis workflow that is discussed in this chapter.

Note on past and future ratings

Operators and developers were able to give also past (a year ago) ratings on Q1, Q1.1 and Q2. In addition, the developers could give expected future ratings (a year from now) on Q1 and Q1.1. These ratings would in theory produce a rough estimate on the past and expected future situation of each task in this area. However, past and future ratings are not analysed in this study as that was not the purpose for including these rating options in the questionnaire.

In fact, many subjects were fairly inexperienced with several tasks one year ago, thus they were not able to give reliable past ratings. Also, the future is notoriously difficult to predict, even for seasoned developers evaluating their own work, and this study is more about the current situation and what should be done to improve it.

The purpose of the past and future ratings was more about providing a frame of reference that might help the subject ponder about the current state of each task. The idea was that it would be easier to estimate current situation more accurately if the subject also thought about the past and expected future (developers only) of each task.

3.4.1 Stage 1 – Gathering questionnaire raw data

The questionnaires produced a vast amount of raw data. Operators answered questions about all tasks while developers answered questions only about the tasks they have been involved with developing.

The operator questionnaire produced **2974** ratings and **906** comments, while the developer questionnaire had **3173** ratings and **455** comments. All the data was input to a summary spreadsheet where operator and developer averages were calculated for each task and question.

3.4.2 Stage 2 – Individual task analysis

Operator and developer ratings and comments were analysed and compared for each task. This individual and detailed task analysis can be found in Appendix 6, and it is the basis for this current state summary.

Operator average ratings for each task

The average developer and operator ratings were calculated for all 73 tasks. See Appendix 4 for the average operator (and developer) severity rating for each question on each task.

The operator average rating for each task is visualized in the figure below and it is based on the operational workflow diagram that was discussed earlier. Tasks are colour coded based on the average operator rating, i.e. the severity of the situation is visualized with a red colour where darker colour indicates a more serious (problematic) situation.

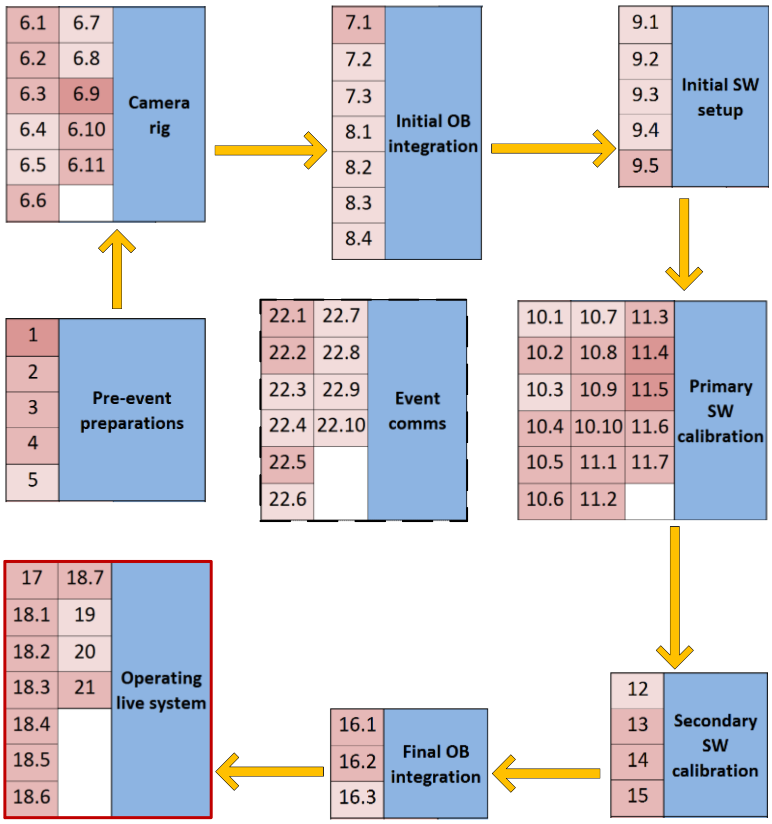

Figure 7. Operator average task severity ratings (light red=not severe, darker red=more severe)

Based on the severity rating of tasks in each work phase, “Pre-event preparations”, “Camera rig”, “Primary SW calibration” and “Operating the live system” seem to be the most problematic phases, which was to be expected.

When looking at Appendix 4, one can see the average operator severity rating for each task, but also the average severity rating for each question on a given task. Interestingly, on a scale from 1 to 5 (good to bad) there are a few tasks where the operator team has ranked the severity of an individual question higher than 4, but none of the tasks have nearly as high average severity ratings. Tasks that are rated most problematic by the operator team (tasks 1, 6.9, 11.4, 11) have an average task severity rating between 3,1 and 3,3. This is surprisingly low considering that the system is known to be somewhat difficult to operate and inherently complicated. Overall, it seems that the operators are, on average, fairly positive about the current system and each task.

Operator and developer average ratings for each question

As mentioned before, possible ratings for each question were always from 1 to 5, from “not severe situation” to “very severe situation”.

Operational scalability rating scale:

- Q1 Usability/clarity
    - 1 - 5 (clear/easy – very unclear/difficult)
- Q1.1 Training difficulty
    - 1 - 5 (clear/easy – very unclear/difficult)
- Q2 Operational risk
    - 1 – 5 (never problems – always problems)
- Q3 Preferred development prioritization
    - 1 – 5 (unimportant – very important)

Note that when discussing the results, the term “developer” refers to **combined** operational -and R&D developer questionnaire data.

Below is a table that indicates average severity ratings for each question from both operators and developers. The *operational scalability* rating for the whole system provides a rough idea on the current state of the system as a whole as it is derived from the average severity ratings for each task (see Appendix 4).

Table 5. Ratings summary (scale from 1=not severe to 5=very severe)

AVG	2.1	2.4	0.3	2.4	2.7	0.3	2.1	2.2	0.1	2.5	2.9	0.4	2.2	2.5	0.3
	operators now	developers now	ΔQ1	operators now	developers now	ΔQ1.1	operators now	developers now	ΔQ2	operators now	developers now	ΔQ3	O-AVG	D-AVG	ΔAVG
	Q1 - System usability			Q1.1 - System training difficulty			Q2 - Operational risk			Q3 - Preferred prioritization			Q AVG - operational scalability		

Operator and developer team average ratings are all fairly close to each other on each question. There are small differences (ΔQ) between operator and developer team average ratings while all are between 2.1-2.9.

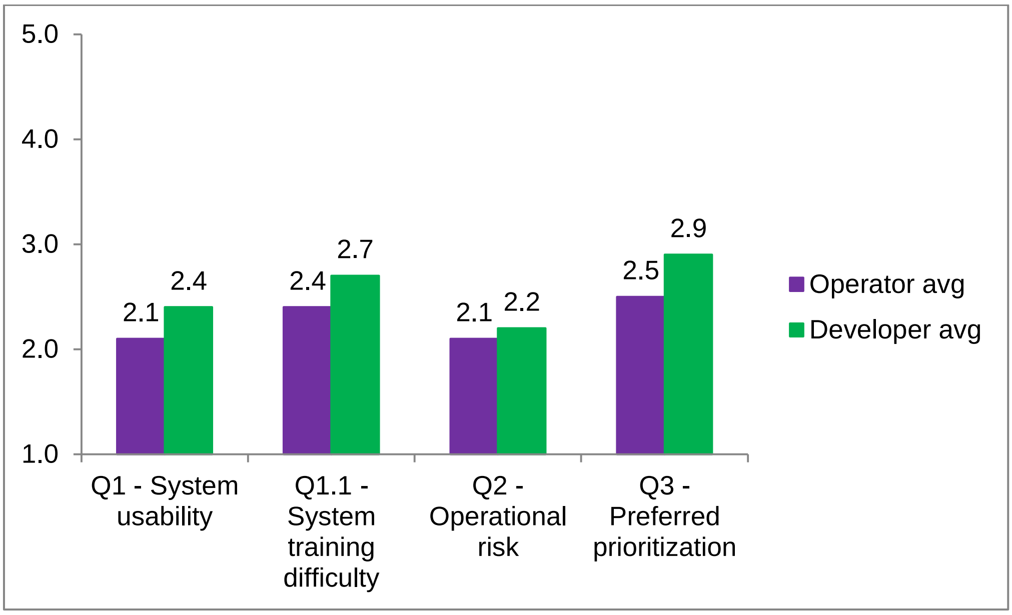

Figure 8. Operator and developer average severity rating for each question (scale from 1=not severe to 5=very severe)

Each question represents a different aspect of operational scalability with the current system. Interestingly, both operators and developers rank current severity of each operational aspect in the same order, from most problematic (severe) to least problematic:

- 1st Preferred prioritization
    - This was ranked highest (highest average score), which was to be expected as the system is still in active development
- 2nd System training difficulty
    - Severity of training difficulty has been well recognized by both parties
- 3rd System usability
    - Severity of system usability is ranked surprisingly low, especially by operators, which indicates that current operators have faith in their abilities and the system
- 4th Operational risk
    - Severity of operational risk is ranked lowest by both parties, which means that operators do not seem to be too overwhelmed by system

problems, while developers appear to be able to concentre on future development goals as opposed to constant problem solving. This is a fairly reassuring finding, as it is clearly a step in the right direction on the path towards large scale operations and events delivered on a routine basis.

The most important finding is that on average the developers seem to rate each question slightly higher than the operators. This is reassuring, since developers should always be more critical towards the system than operators, rather overestimating the severity of the current situation than underestimating it. This is also why there is a green (“OK”) status flag next to each result (ΔQ) in table 5. The green flag means that developers seem to recognize, and sometimes even slightly overestimate, the current severity of each question when compared to the operator average.

Overall, it seems that developers recognize the current state of operational scalability well and even overestimate the severity of the current situation slightly. However, this was to be expected as all successful development should at least match the end-users average requirements and expectations. While this is good news for the overall development, it can be somewhat misleading as there are many individual tasks that are underestimated by the developers and deserve a closer look. This is exactly what will be discussed in Theme 1, which is about ensuring that system development fully meets operator expectations.

Furthermore, operator and developer comments indicated *why* tasks were perceived problematic and important to develop. Therefore, based on individual task analysis on the comments and ratings as a whole, also other themes began to emerge. Operators seem to call for improved communication (Theme 2), while they also seem to lack the technical skills and knowledge to operate certain aspects directly and indirectly related to the system (Theme 3), which is not made any easier by the complicated user interface that lacks automation and feedback (Theme 4).

3.4.3 Stage 3 – Identified re-occurring Themes

Based on the detailed task analysis (Appendix 6) on all ratings and comments, the abovementioned themes were identified. These key challenges summarize the problematic areas with the current system. Specific development ideas emerging from (or inspired by) the questionnaire and the theoretical framework will be discussed in more detail later on in the proposed action plan chapter.

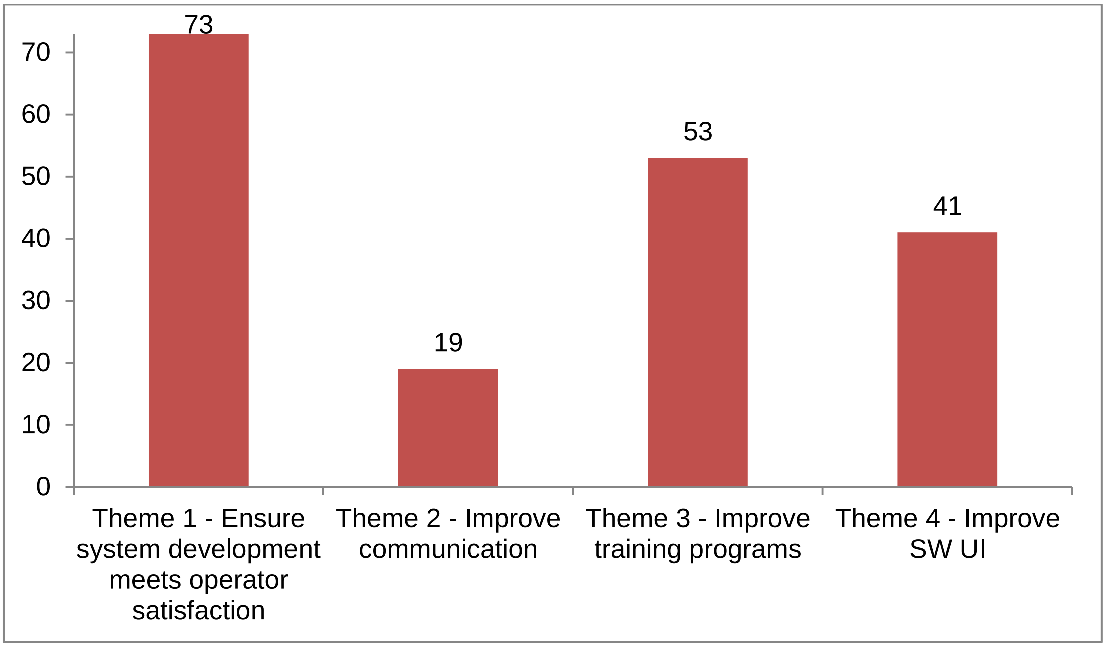

Figure 9. Tasks per theme

In figure 9 above, each Theme is presented based on how many tasks (of the 73) each Theme can be applied to. See Appendix 2 for a more detailed list of all tasks and how identified themes relate to each task.

Theme 1 - Ensure system development meets operator satisfaction

This first theme concerns all 73 tasks, directly or indirectly, as system development is not restricted to just technological development, but it is also about operational processes and the whole workflow. As discussed before, operators can be critical towards the system, but developers should be even more critical, as it would be much more dangerous to underestimate operator expectations and development requirements than to overestimate them. Overall, the developers seem to recognize operator requirements for the system very well, but based on the individual task analysis (Appendix 6), there are many individual tasks where this is not the case.

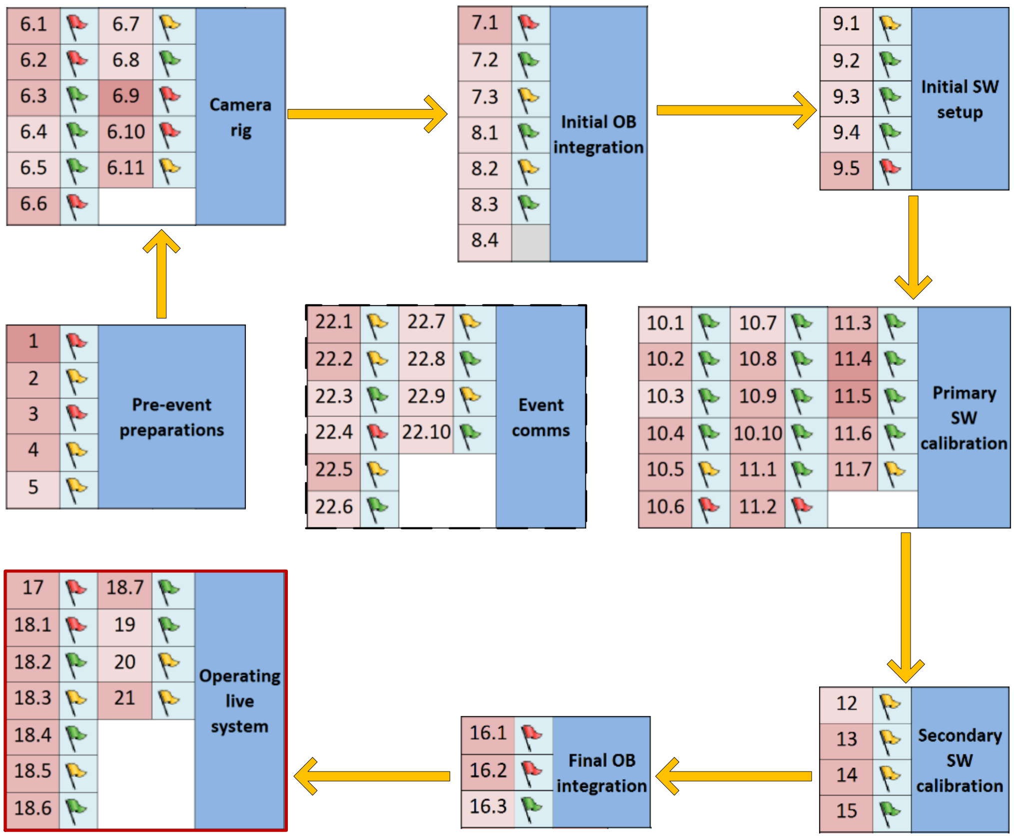

Figure 10. Operator average task ratings and developer recognition (flags)

Figure 10 is otherwise the same as figure 7 presented earlier, but now there are coloured flags next to each task. These flags indicate how well developers have recognized (matched) operator ratings on each task.

Green flag

- Developers fully recognize the operational severity of the task
- This means that the average developer rating for each question about the task (Q1, Q1.1, Q2, and Q3) is either the same or higher than the average operator rating. This means that developers fully recognize the task importance on all areas: usability, training difficulty, operational risk and preferred development prioritization

Yellow flag

- Developers slightly underestimate the operational severity of the task
- This is a minor warning and it indicates that one or more questions about the task is rated slightly lower (Δ -0.1 to -0.4) by the developer team

Red flag

- Developers underestimate the operational severity of the task
- The red flag is a more serious warning and it indicates that one or more questions about the task is rated considerably lower (<Δ-0.4) by the developer team

The yellow flag is not a critical warning as the difference is still fairly small and ratings are always somewhat subjective, but it is something that should still be looked at by the developers. The red flag is more important and developers should pay close attention to tasks that have received a red flag as they might not be adequately recognizing and addressing operator expectations in developing these tasks.

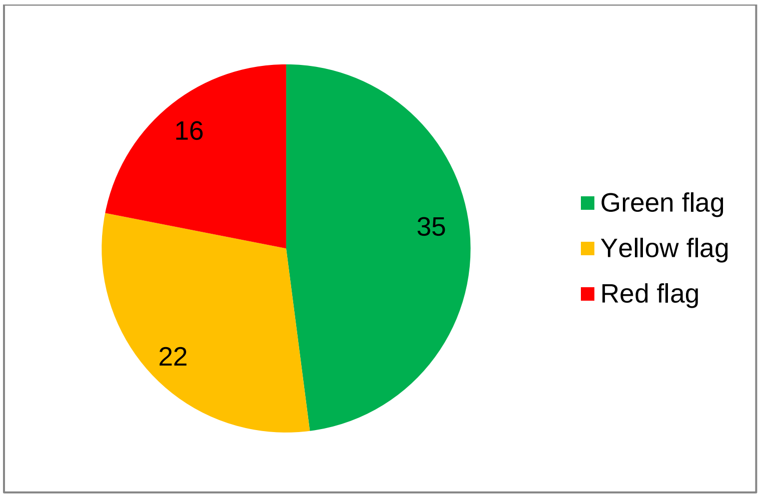

Figure 11. How the 73 tasks are flagged

In conclusion, many tasks require increased developer attention. Red (16 tasks) and yellow (22 tasks) flags are fairly evenly distributed between tasks at different operational phases (Figure 10).

Theme 2 - Improve communication

Communication affects 26 % of the 73 tasks. Specific communication “tasks” (22) were separated in the operational workflow, but communication also affects many tasks indirectly. That being said, there were some non-communication specific tasks where communication problems seemed to cause the biggest problems for the operators.

First of all, operators reported internal communication problems during the pre-event preparations stage. Issues seem to revolve around operators not being involved enough in the production planning process. Sometimes there seems to be lack of information, or information being distorted, when it reaches the operators, since information is not always stored in a centralized place whenever email is used as a communication medium. Operators understand that crew allocation and scheduling for events is challenging with a small operator team, but they would like to know what they will be doing and when -with much more notice. Operators would like to be notified immediately when crew assignments are confirmed or cancelled, and they would also like to be more involved with the travel arrangements. Not surprisingly, developers have recognized operator concerns about scheduling and are working towards a longer notice for crew allocation.

During the event, some operators are worried about the lack of remote technical support, as currently there are no official support channels available. Developers, on the other hand, are aware of the issue, but did not provide any concrete suggestions on how this could be improved in the future. Operators have also noticed practical communication problems at events, for example communication HW and its dependency on the host broadcaster, while developers have mixed feelings on the validity of the issue. Events can also be overwhelming with a lot of issues to report and operators are worried about remembering everything when writing the post event report for the developers.

In addition, external communication problems were also reported. However, it seems that these external communication problems were mostly with the host broadcaster, and related to confusion about pre-event planning, broadcast integration and the fact that both parties do not fully understand each other’s technology. The need to improve external communication to broadcasters during pre-event planning is something that developers have recognized as well, and are already working on so it will not be looked at very closely in this study. Also, broadcaster awareness on the technology and scheduling requirements will only improve gradually, as they do more events with the company, but increasing operator awareness on broadcast technology and terminology is something that deserves a closer look at, as it would indirectly improve also communication. However, this will be discussed in more detail in Theme 3 about training programs.

It can also be argued that communication problems are indirectly related to practically every task in terms of operator-developer communication. Efficient communication between operators and developers is closely associated with ensuring end-user requirements and satisfaction, so this communication aspect is discussed in more detail in Theme 1.

Therefore, this theme concentrates on improving internal communication from an organizational and operator perspective, while external communication is also briefly looked at.

Theme 3 - Improve training programs

This theme relates to 73% of the 73 tasks, and operators and developers alike recognize the importance of training. In the long term it may be most feasible for the company to train outsourced and freelance operators who would form teams lead by an experienced, full time system operators. Currently the company is training several outsourced operators to perform the HW rig, i.e. the mechanical camera setup. The idea is to continue training outsourced operators and gradually expose them to also other aspects (SW, integration) of the system at live events, ultimately making them fully capable system operators.

It seems that while full time operators seem to understand the system fairly well, there are still many technical aspects that they either have trouble understanding, or are uncomfortable with, due to the complexity of the system, but often also because they lack the operating experience. For many tasks, there is no other way of gaining more experience than operating in live conditions, which is not ideal as there is no room for trial and error in this high pressure live broadcast environment. Therefore, this situation could be greatly improved by some kind of simulator training system.

While operators lack understanding or experience on some technical aspects of the system, they may be even more confused about the arguably simpler and more standardized host broadcast systems they have to integrate with. This is only natural as operators are not intended to be expert broadcasters, but expert system operators for the company. However, increasing understanding on how the neighbouring broadcast systems work should make all integration related tasks much easier and straightforward. When operating in different countries operators might not share a common language with host OB crews, but what makes things even more difficulty is that they use totally different technical terminology as well. On many occasions operators need to explain and “teach” the host engineer how the system works in order to solve integration problems. This would be much easier and quicker if operators were better aware of the broadcast technology used by the broadcaster, thus better equipped to solve integration problems on their side as well. Increasing broadcast technology awareness is something that should also be emphasized at the developer side, as the majority of developers do not possess a background in broadcasting, thus lacking the practical experience on broadcast technologies that the system is integrated with at live events.

Theme 4 - Improve SW UI

This final theme relates to all SW related tasks, 56% of the 73 tasks. The current user interface seems to be problematic in terms of usability from an operator perspective. It seems that operators manage to work with the UI in the calibration stage where there is generally time and room for trial and error, but during the live operation the UI gets too awkward and distracting to use efficiently.

Naturally, software automation on many tasks is something that operators call for frequently and ideally everything should be automated, but this is realistic only in the long term, if ever. Operators seem to understand this to some degree, so they often ask for more fluent and less distracting controls, and if full system automation is not possible, then at least more automated feedback from the SW. Generally, this feedback should include alarms or some level of guidance based on live system status, operating environment, and operator actions and adjustments.

The company has experienced SW developers who have the know-how to develop robust UIs, which is why UI development will not be looked at during the literature analysis, though some useful findings may emerge from the analysis related to the other themes.

3.5 Summary

The company and its system development workflow and technology were first introduced briefly. Current system development is somewhat compartmentalized, which seems to be necessary in order to manage development efficiently. However, the downside is that developers might not fully understand operator requirements, and vice versa.

The questionnaires provided a lot of data on the perceived operational workflow from both operators and developers. This data was analysed and findings were presented.

The average operator (severity) ratings were surprisingly low for each of the four questions and on average lower than the developer ratings, which was a reassuring finding as developers should always be more critical towards the system they are developing. Interestingly, both operators and developers ranked different aspects of operational scalability (questions) in the same order. Both stakeholders realized that the system is still in active development, and current training difficulty and usability are well-recognized problems. The operational risk was rated lowest, which is reassuring as it indicates that operators can concentrate on operating on a routine basis, while developers can concentrate on future development as opposed to continuous support for solving new problems encountered at the field.

However, there was more variation in the individual task ratings, and many tasks were highlighted for increased developer attention for future development, which essentially formed *Theme 1* about meeting operator expectations in all system development. Based on the comments data, also other themes began to emerge. It was identified that communication (*Theme 2*), training programs (*Theme 3*) and the software UI (*Theme 4*) all need to be improved in order to enhance the operational scalability of the system.

4 Best practises

In this chapter, existing literature and theory related to the identified Themes is analysed and summarized into a theoretical framework. Ideas and strategies are expected to emerge from the theory. These will be incorporated into the Action Plan in the following chapter.

4.1 Theme 1 - Ensuring system development meets end-user satisfaction

Making sure that operator requirements are met in information system development is all about ensuring final end-user satisfaction. No matter how good and powerful a system is, it has no practical value if the end-users do not perceive it as such. Existing literature on SW development generally defines “user satisfaction” as the most common measure for a successful system, as it is directly related to system effectiveness through end-user performance. Therefore, ensuring end-user satisfaction should be an important goal in all information systems development. All in all, there are many potential factors affecting user satisfaction and also developer satisfaction, which is important to take into consideration, especially if the two parties are working in co-operation. (Subramanyam &al, 2010: 140; Procaccino and Verner, 2009: 114)

Suitability in terms of perceived benefits and usefulness

Perceived benefits and usefulness are reoccurring factors emerging from literature and deserve to be mentioned here briefly. However, the system is not like a regular IT system intended for increasing end-user performance and productivity, nor is it competing with alternative systems for end-user usage, as operators do not have any other chance but to use this system. This is why these factors are more fitting for regular IT systems where there are potential, alternative systems available, that end-users could choose based on perceived benefits and usefulness. (Mahdmood &al, 2000: 753,764)

User expectations

It is suggested that meeting end-user expectations equals achieved end-user satisfaction, thus satisfaction is seen more likely with a system that recognizes and meets end-user requirements. Recognizing end-user expectations in system development seems to have a direct correlation with eventual system performance. However, it is important that end-user expectations are managed and kept at a realistic level, so that the end-users fully understand the potentials and limitations of the system and do not get carried away with their expectations, and ultimately end up dissatisfied with the system. (Procaccino and Verner, 2009: 114; Mahdmood &al, 2000: 754, 764; Liu &al, 2006: 1, 4).

User experience & skill

Perceived behaviour control, which means users confidence (based on their skills and experience) to operate and take on the system, has a direct impact on user satisfaction and perceived usability. The skill and experience level of intended users should first be mapped out before implementing any new systems or updates, ideally even before actual design and development. If a system stretches the technical capabilities of the end-users, it needs to be taken into account during system deployment and compensated by additional training. Recognizing the end-user skill and experience level is especially important when users are taking part in system development as the development team tries to formulate realistic and feasible system requirements based on user input. Inexperienced users may have unrealistic expectations and are less likely to contribute as well as experienced users, so they would need to be trained before they can take part. (Liu &al, 2006: 1,4; Procaccino and Verner, 2009: 115; Mahdmood &al, 2000: 755,767; Kanter, 2000: 72,75)

Consequently, mapping out and maintaining a coherent picture on operator experience and skills is something that should also be applied to company operators, as the system really stretches their technical capabilities and new system updates may often require supportive training.

Ease of use

There are many arguments that highlight the importance of usability. When a system is easy to learn and to use it requires less effort and time from the end-user, which will eventually save resources and increase overall job performance. Information technology is meant to be a tool for the end-user and not a task itself, which is sometimes forgotten by developers who may have a very techno centric approach towards development, and may in fact define usability somewhat differently than the end-users. (Mahdmood &al, 2000: 754; Kanter, 2000: 70,75; Procaccino and Verner, 2009: 114)

Because developers are generally very technically talented people, they have traditionally built not only the system, but also the user interface in their own image. This can be a problem as users are rarely as technically oriented and may even spend less time with the system and often in fairly different operating conditions. Developers may understand the system intricately, but often lack understanding on the actual operating environment and operator requirements. Developers can be very creative, but may also tend to concentrate on increasing system performance in very sophisticated ways as opposed to making development and deployment easier. The importance of a good user interface cannot be highlighted enough as better results will always be achieved with mediocre technology and a very good interface, as opposed to perfect technology with a poor user interface. (Kanter, 2000: 70-71,75)

This overlaps somewhat with Theme 4 on improving the UI, as the company has a very talented and techno-centric team of developers, but a not as technically oriented operator force.

It is suggested that user interface standardization does not guarantee ease of use, but it is generally seen as a strong foundation for system development. However, on some systems, usability has been improved by increasing user customization for the user interface by utilizing behavioural end-user background data mining. Because there may be different classes and levels of expertise among the users, customizing multiple user interfaces might work well for some systems. (Kanter, 2000: 71,74,75)

Perhaps the system could also somehow be improved by means of end-user background data mining. This system is an expert system and the operator interface (Theme 4 again) cannot be customized for different operator skill levels, but perhaps something could be done and this will be discussed with Theme 4.

Whenever new system upgrades are developed, it is also important to try and maintain a sense of familiarity, or “relative compatibility”, in all new components so they are easier for existing users to accept and learn, which is something that applies also to the development of the system. Another efficient way to improve usability is to arrange usability tests in lab conditions for all new system upgrades that are about to be deployed, but also during system roll-out phase in a real, but controlled environment. This would hopefully indicate any design flaws that hinder usability at a stage where something can still be done about any emerging issues. (Kanter, 2000: 75-76)

The company is already testing extensively in laboratory conditions, but testing in a real live broadcast environment has been done rarely as the broadcast is always the first priority. However, there might be ways to safely perform parallel testing while operating a live event and it would definitely be worth looking at.

User involvement in system development

User participation in system development is seen as an efficient way to improve feedback and increase user satisfaction and acceptance. User involvement evokes “a sense of ownerships” towards the system as users feel more committed when they are somehow involved in the development and decision making process. However, if not managed efficiently, it poses a risk to the development process, as the project may also become more difficult, time consuming and less effective. (Procaccino and Verner, 2009: 115; Subramanyam &al, 2010: 137)

End-users who are more involved benefit not only the development effort by sharing first-hand experience and information on the actual system operating environment, but they also feel more motivated and personally connected with the system. Eventually, user lead development might even produce organizational and business benefits. Specific perks include for example the following: mapping out an accurate representation of user requirements, understanding the system operating environment, avoiding unnecessary feature development while concentrating on the essential features, joint development decisions to help solve problematic design issues, less user resistance for changes, and more motivated and committed end-users who are more likely to succeed. When end-users are involved, they will also learn, as their experience and skills are increased during the process. (Mahdmood &al, 2000: 755,767)

However, it is also highlighted that information systems should always be developed in accordance with end-user capabilities and skills. Therefore, as mentioned before, end-user experience and skills should ideally be mapped out before they can affect any system development decisions, especially if inexperienced end-users are involved in the development process as their contribution is not yet reliable and they should first gather more experience, for example through system training. While developers should recognize end-user expertise on the actual system operating requirements, it is also important to remember that end-users are not working as developers and the additional workload needs to be balanced with their primary duties. (Mahdmood &al, 2000: 754,767; Procaccino and Verner, 2009: 113-114)

Another efficient way to improve communication and trust between developers and end-users, especially if they are geographically separated, is arranging frequent visits between the two stakeholders. This is a good way to narrow the perception gab between these two stakeholders. Visits can be short or long as long as they are organized and scheduled well. However, while trust needs to exist between developers and end-users, it does not mean that the end-users should not verify development QA (quality assurance) findings and methods. This is even more important when the end-users and developers are geographically separated and the end-users should be reviewing the developers test procedures and make sure future development design is going to be appropriate. (Ramesh &al, 2006: 44-45).

The company should definitely look into increasing developer involvement in operations, if only to learn from the end-users, to build trust, and to improve informal organizational communication. The organization is distributed between different countries, so it is also a valid point that operational representatives should review and analyse all QA testing procedures and plans, in order to make sure they match with reality.

Due to the different skill levels and backgrounds, users and developers may have conflicting interests during the development process, which may have adverse effects on the development process and increase costs. Therefore, it is equally important that developer satisfaction is also met during the process, as developers need to feel comfortable with end-user involvement. This is why it is crucial to manage the level of user participation, whether it is new system development or less complicated projects that involve maintenance of existing systems. General duties for end-users could be specifying and prioritizing system requirements or features, input and testing for prototypes, and taking part in development meetings. (Subramanyam &al, 2010: 137)

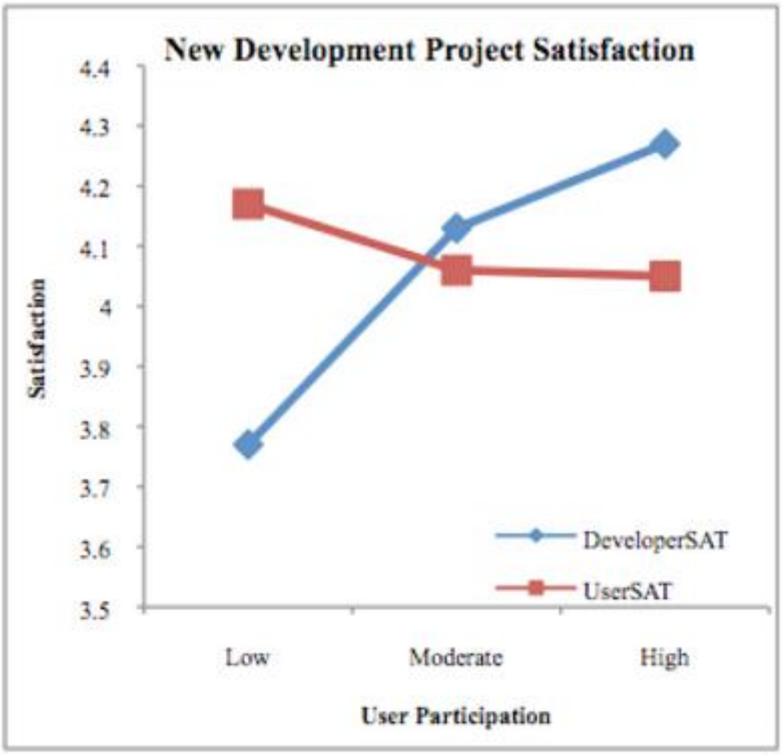

Figure 12. End-user involvement and satisfaction vs. developer satisfaction in new development projects (Subramanyam &al, 2010: 138)

Figure 12 is a diagram from a study that looked at a large pool of survey studies on perceived satisfaction from both end-user and developer perspective in different SW development projects that had different levels of co-operation between the two stakeholders. (Subramanyam &al, 2010: 138)

Since new system development projects can be extremely demanding and complicated, they require strong coordination and continuous end-user input. Therefore, developers will always value higher levels of user input and their satisfaction depends upon it. The perception gab between users and developers is widest with low user participation. This is because developers lack user input, which makes it very difficult to plan and design system features, as they are being kept in the dark about any actual user requirements. The users are fairly content, but only because they are not that involved, thus not knowing any better and not expecting much more from the system. When end-users get moderately involved they start to understand potential system enhancements better and their output will be more valuable for the developers, whose satisfaction increases accordingly. Consequently, during the process, user satisfaction is lowered as they begin to understand how good the system could be as opposed to how good it actually is. This trend is even stronger when users become heavily involved with the development process as their demands get more advanced and perhaps somewhat unrealistic or unfeasible for developers to meet. This is why at this point user satisfaction is at its lowest as developers fail to fulfill their demands for a system that the users have envisioned (figure 13). (Subramanyam &al, 2010: 139)

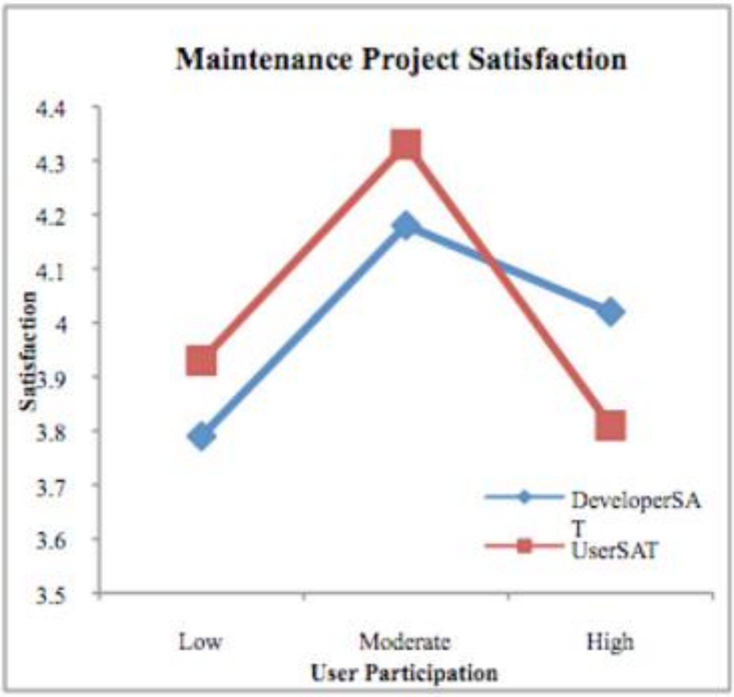

Figure 13. End-user involvement and satisfaction vs. developer satisfaction in maintenance projects (Subramanyam &al, 2010: 139)

On a less demanding development project (figure 13), where an existing system is maintained, the graphs look somewhat different. Software maintenance projects rely on the quality of the existing software and how easy it is to understand and maintain. Maintenance relies on understanding how the original SW works, and this is what the users, who have the most practical experience on the system, can help the developers understand. Because the system is not new like in the previous development example, the operators are likely to want to take part and contribute in this maintenance process. This is why both user and developer satisfaction are both very low when users are not very involved with the development, and at their highest when users are moderately involved. However, when user involvement is high, satisfaction of both parties is very low again, as operators tend to start making frequent and too complicated requests for maintenance projects, which are generally meant to be kept low key and simple, which will in turn frustrate the developers. (Subramanyam &al, 2010: 139)

In conclusion, it is important to manage the perception gab between operator involvement and the corresponding satisfaction of users and developers alike. It seems that moderate user involvement with the smallest perception gab is a good compromise for both new system development and maintenance projects, which both apply to the development of the system. Essentially, users should be given a chance to provide input based on their expertise on the actual system requirements, while developers should learn from them while still maintaining control. This is where project managers or key users should act as strong mediators and make sure expectations of both parties are maintained at a realistic level. Managers should manage user feedback and make sure it is heard, but also try to filter only the relevant information to the developers. (Subramanyam &al, 2010: 141)

However, often user feedback is very strong and audible from the managers or key users who may be system experts themselves and personally involved in the development process. This poses a risk that filtered end-user feedback does not fully represent the views of the less skilled end-users. This is why it is important to also acquire qualitative and quantitative feedback from all of the end-users. One way to do this is to perform pre-prepared questionnaires, much like was done in this research project on the system, while the other method is informal user observation and discussions. (Kanter, 2000: 76)

Finally, end-user involvement seems to be especially important with complicated expert systems such as the one being studied here, where user requirements are unclear at first, but gradually found out during an iterative development process. This also highlights the tight communication requirements between end-users and key developers albeit through a managerial filter. (Mahdmood &al, 2000: 755)

The system is currently exactly at this stage where end-user requirements are gradually becoming clearer, as more field experience is being gathered at a fastening phase. The questionnaire performed in this study provided both qualitative and quantitative feedback on actual operator requirements without a managerial filter. In the future, it seems clear that operators should be more involved with current system development while maintaining a moderate level of participation, which should also ensure developer satisfaction in the process. The current development method where operators relay their input through “a managerial systems expert filter” is a good starting point, but perhaps something could be done to improve quality, to increase the amount of operator input, and to make sure it is better recognized in the development process on a more regular and controlled basis.

Organizational support

Organizational support refers to how the organization is able to support system development, operation and training. The end-users may lack required SW - or HW knowledge so setting up appropriate support channels is essential. Perceived support service quality has a direct effect on end-user satisfaction, which is why developers need to maintain a high quality support service for the users. In practice, this support may come from training, colleagues or manuals. However, it is important to bear in mind that though essential, support is often a hidden cost as productive time is being spent on talking to colleagues or finding solutions to operating problems. It is estimated that this hidden cost can be as high as two-and-a-half times the known hardware and software cost, in terms of productive operating time lost during time spent on solving these issues. (Kanter, 2000: 76)

This point applies to the company quite well as setting up remote support channels is something that has not been officially done yet. Generally, off duty operators or developers can be contacted from events, but officially there is no remote support program with designated personnel on standby for each event. However, this will be discussed in more detail with Theme 2 about communication.

Training programs are also highlighted as they are directly linked to end-user experience and skills that in turn affect the end-users confidence to perform with the system to the best of their abilities, which is exactly why setting up training programs is discussed later on in more detail with Theme 3. (Mahdmood &al, 2000: 756; Liu &al, 2006: 2)

Conclusions

It seems that ensuring sufficient, though moderate, end-user involvement in product development through a managerial filter is important for improving end-user satisfaction, while their requirements, expectations and expertise on the system must be recognized in the development process, which should eventually lead to a more usable system. At the same time, an efficient support network needs to be setup and also maintained.

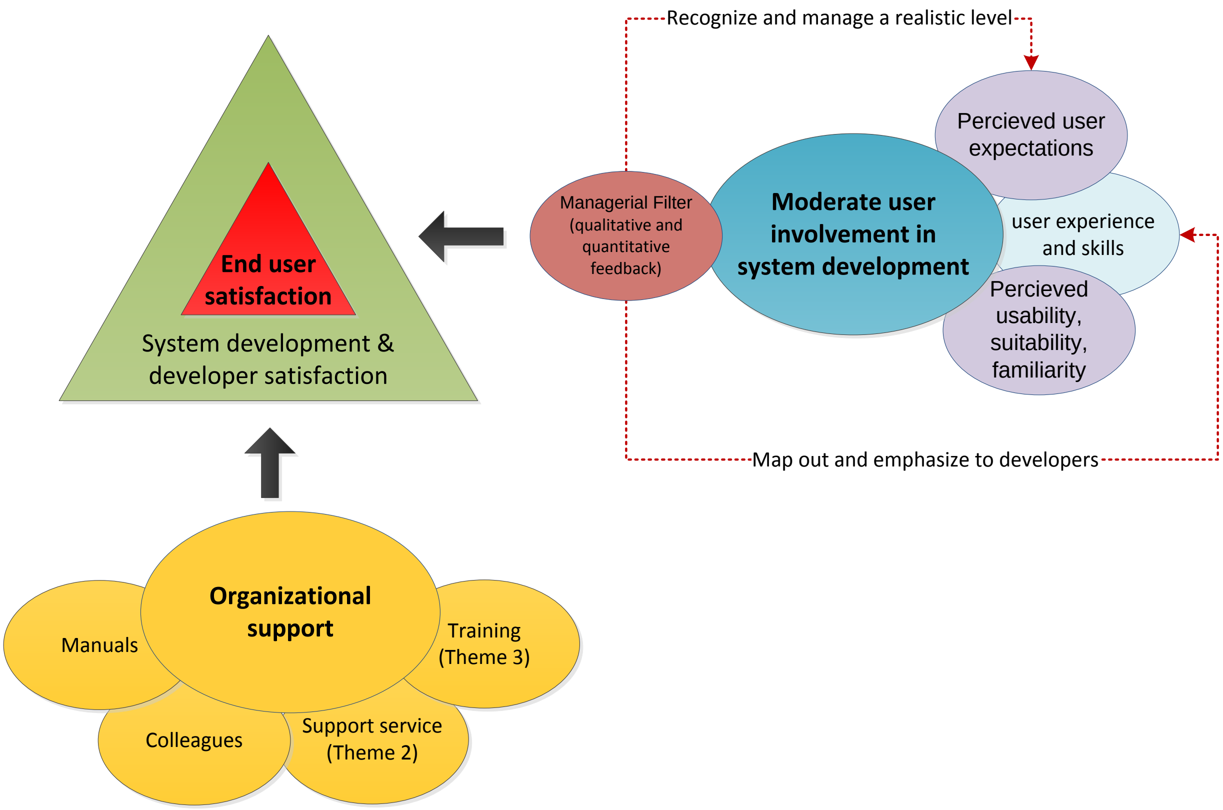

Figure 14. Factors affecting end-user satisfaction – overview

4.2 Theme 2 - Improving communication

Internal communication is all about building relationships and trust between different levels of management and employees, where managers manage and influence this process. Generally, employees want to know and understand the direction their organization is heading to and how they are able to contribute to the process, while the CEO of the company defines the way internal and external communication is performed in the company. Other top managers are in an important position where they can exert their personal influence to employee relations, satisfaction and attitudes, all of which ensure that employees are well informed and able to represent the company to external parties. Employees are generally seen as credible sources by the external stakeholders, so effective internal communication should indirectly enhance also external communication. (White &al, 2010: 66)

Frequent interpersonal communication between management and employees is generally seen as very important. Often employees prefer to receive their information directly from as high as possible. This will not only add credibility to the information, but potentially reduces uneven information distribution through middlemen and other bottlenecks through the organizational chain of hierarchy that may sometimes filter or distort the originally intended meaning of the message. Employees, who do not have sufficient access to supervisors and do not trust the information trickled down the organizational chain, will most likely feel like they are not a valued part of the work community. (White &al, 2010: 66,72,76)

Information sharing

Two types of information sharing characteristics can often be found in existing literature: “quality –and quantity of information”. Quality refers to how exact and useful the information is and whether it is shared in a timely manner. Managing the amount of information being communicated is all about “quantity of information”, sometimes also referred to as “information adequacy”, which means maintaining a delicate balance between information needed and the information received so the recipients will be content. This means that too little information will cause distrust and rumors, while too much information is generally ignored and the intended message gets lost. Efficient internal communication must also have the same message as external (public) communication, otherwise employees may feel like they are being kept in the dark and might start spreading rumors. Furthermore, in this case they would be less likely to defend the organization to the outside world. (Thomas &al, 2009: 290-291; White &al, 2010: 69)

It seems that a well “trusted” manager generally ensures both factors are met when communicating information to employees. It has also been studied that quality of information may generally be more important for a new employee during the first 1-3 months with quantity becoming more important after that. (Thomas &al, 2009: 290-291)

Managers may not always understand what is seen as “common knowledge” within the company and what should be emphasized in communication instead. When something is communicated, managers do not always keep track of what happens to the message after it has been communicated, and may falsely assume that the recipients understand all the information being conveyed. It is often a conscious decision from the manager whether he chooses to relay a piece of information or not. These “information voids” generally occur when the manager fails to communicate an important piece of information either because he assumes information has already been communicated through other channels by someone else, or that it has been common knowledge all along. This is why increasing redundancy in communication channels leads to better internal communication (Stainback, 2012: 31; White &al, 2010: 73,79)

As mentioned before, information sharing needs to be accurate, useful and presented in a timely manner. In order to do this, the company would need to chart its ability to deliver what employees would consider important information. In practice, this means finding out what is the important information, is it reaching the employees, is it accurate and useful, do they get it in time and from the right people, and is the used communication medium the correct one, especially when using electronic communication. (Thomas &al, 2009: 305)

Increasing redundancy in the company’s communication channels is definitely something to look at, since the questionnaires provided data on where and what kind of important information is not reaching the operators efficiently due to communication bottlenecks and inefficient mediums.

Maintaining constant communication is important. This can be achieved for example by having short daily meetings to identify current issues, track the status of projects, and discuss new ideas or critique. Electronic medium can be utilized with instant messaging and video conferencing used for more important meetings. These days, mobile phones enable key personnel and managers to be “on call” most of the time and even outside normal working hours. However, this does introduce additional stress to these people and hidden costs in terms of lost productivity while on remote support duties. Again, this highlights importance of setting up official remote support channels for operators as already mentioned in Theme 1. (Ramesh &al, 2006: 44)

Trust and organizational openness

Communication has a major role in ensuring the employees trust towards the company, and their colleagues and managers. It is all about building social capital, increasing employee involvement and performance, while improving organizational openness in terms of encouraged information sharing among employees. Information sharing is based on trust, which is essentially belief in another party shaped by the information and experience available. When more information is shared, trust will generally increase, while the lack of communication will have exactly the oppose effect. (Thomas &al, 2009: 288-290)

Interestingly, the quality of information is seen as more important than quantity when it comes to building trust between managers and employees, while quantity is more important when considering trust between top management and employees. This may be because information from the top managers is generally more abstract and about the “big picture”, as opposed to direct information related to employee’s individual duties. This is where top managers often have to rely on managers to filter this abstract information and specify and forward the task related information to the employees. Therefore, top managers are trusted to provide the high-level strategy and goals for the organization, while managers are trusted to instruct individual employees on how they can perform their jobs in order to meet these high level goals. (Thomas &al, 2009: 302-303, 305).

Organizational openness is all about ideas being discussed and shared openly, even if they are not popular among the management or the majority of the company. Employees are more likely to support organizational goals set by top management if this kind of open communication atmosphere prevails and communication is not formally controlled too much. Furthermore, an informal communication environment cannot exist if there is not enough “trust” within a company, as employees need to feel that the organization is a safe place to express oneself. However, there are also risks involved with informal communication, especially between teams, as it may become too informal and lead to miscommunication when individuals begin to convey mixed messages. This is why informal communication between larger groups should be managed on some level by someone designated as the main point of contact, who will formally facilitate communication between teams. Another way to improve the efficiency of informal communication is to support it with documentation, where the most critical issues are more coherently displayed. (Thomas &al, 2009: 291-292,303,305; Ramesh &al, 2006: 44-45)

As a fairly small business, the company is a somewhat open organization as far as internal communication is considered. The communication atmosphere is fairly open, while communication is being managed between operators and developers through a managerial filter as discussed in the preceding chapter on Theme 1. However, communication bottlenecks have been recognized in the questionnaires, which is why it is clear that the company should look into introducing a bit more control, while making sure communication remains coherent.

Increasing trust towards the top management is more about making sure that the organization is providing an adequate quantity of information, as trust in top management is generally much more impersonal and based on indirect observations on larger organizational features and the related decision outcomes made by top managers. (Thomas &al, 2009: 305)

It is also important to build a cohesive team culture, where teams are ideally formed from people who have already built existing work relationships with each other and collectively possess the required skills and experience to get the job done. Like all valuable resources, people with high skill levels are generally scarce and in high demand, which poses a challenge when forming teams. Team builders can either assign “good enough” teams with different people of varying skill levels, or form elite high-performance teams with the key employees. (Ramesh &al, 2006: 45)

At the moment, and in the near future, the company is too limited on experienced operators to build elite operator teams, and they are automatically distributed between different teams, which also supports learning of less experienced team members as they need to take on more responsibility when there is only one expert level operator present. Therefore, high performance operator teams would be formed only temporarily for especially challenging events.

Information requirements and employee backgrounds

Communication and organizational culture co-exist in a company, where the latter mentioned refers to how employees feel they fit in the organization through personal involvement and commitment. Employees have different backgrounds, skills and experience levels that affect their individual expectations on communication quality and information requirements. This is very similar to user experience affecting development expectations as discussed earlier on Theme 1. Because of this, a standard communication approach that fits all employees equally is seen as highly ineffective. (White &al, 2010: 70)

Lower level employees may often believe they receive all the required information as long as they are able to do their job. People working in middle management often want to be more involved and aware of everything, and may want more information that they actually need. However, all employees generally want to be “kept on the loop” on all major things happening or being planned for the future that might have direct or indirect effects on their jobs, and if they feel misinformed it has a direct effect on their work morale. (White &al, 2010: 73,76,80)

This also applies to the company, as managers seem to be well informed, while operators want to be informed mainly about things relevant to their work duties. Furthermore, as mentioned before, there were some communication bottlenecks identified in the study and all of the required information does not always reach the operators,

Dense communication

Companies should recognize the importance of making communications *leaner* in order to improve productivity and save costs. In practice, this involves eliminating what is known as “communication waste”, which can be compared to any other form of waste found in manufacturing. This waste consists of over communication, under communication, superfluous communication and unnecessary communication. (Stainback, 2012: 35)

Nonspecific and qualitative communication is generally fairly inefficient, whereas efficient communication is often quantitatively “dense”, which means that communication should be specific, with meaningful remarks or comments that describe the issue in a short but very detailed manner. This is especially important in fast-paced dynamic environments that require quick decisions that should be based on direct, quick and informative feedback. Furthermore, communication density is especially highlighted with technical discussions as they generally require relaying information that is more difficult to comprehend, especially when short on time. (Stainback, 2012: 32-34)

Cultural differences

Electronic and traditional communication practices may both differ quite a lot between different organizations, and even departments within those organizations. This becomes especially evident when different geographical cultures are involved. Some cultures are seen as “high-context”, where messages are communicated fairly implicitly, while in “low context” cultures they are communicated “explicitly” and accurately. Therefore, organizations should try to establish processes that mitigate cultural communication problems, as they may otherwise cause cultural clashes. (Kupritz and Cowell, 2011: 63)

This applies to the company’s external communication quite well, as most of the events take place in Spain and Italy, which are categorized as “high-context” cultures, while the company is a Finnish-English company where employees are from a “low-context” culture.

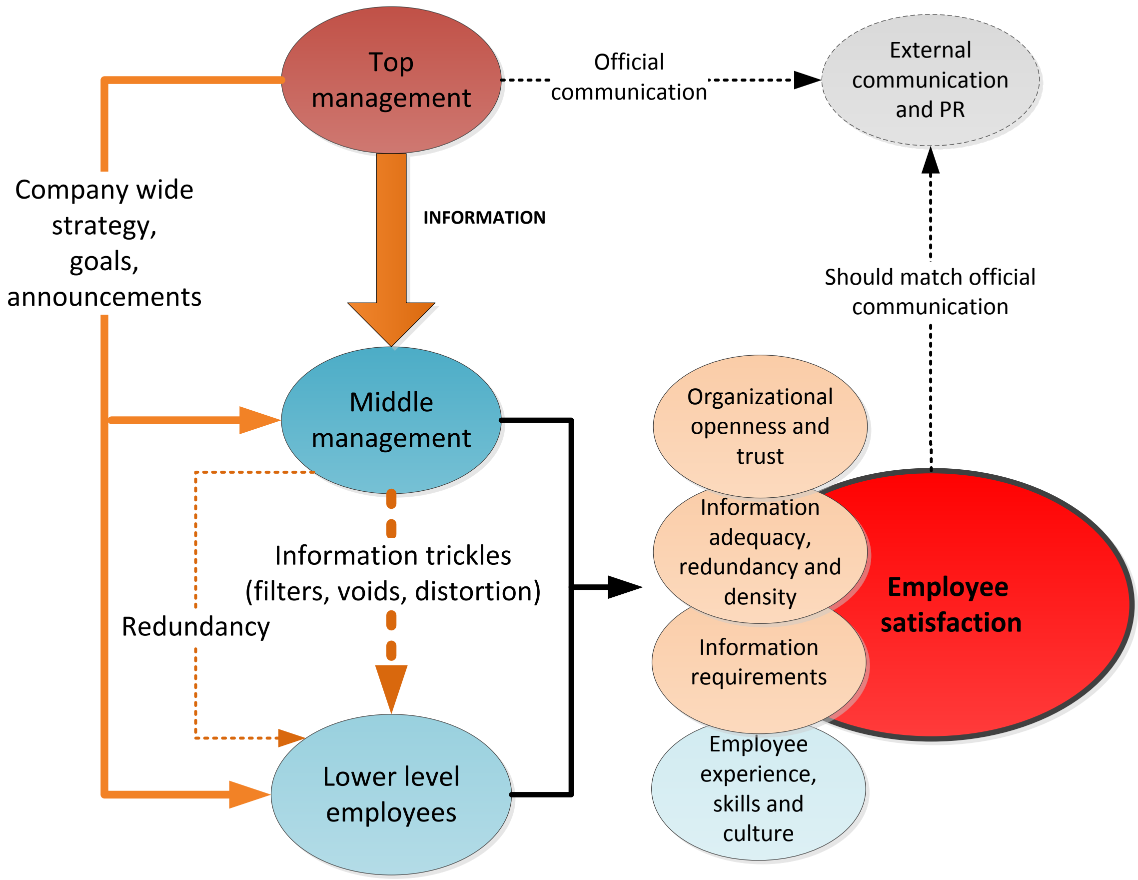

Figure 15. Factors affecting communication efficiency – detailed

Communication mediums

Choosing the right communication mediums makes all the difference when managing communication. Next, the most important mediums are discussed and they can be roughly divided into two categories: traditional physical interaction and modern electronic methods.

Face-to-face communication

Face-to-face conversations, whether planned or co-incidental, often take more time and resources so they can be more costly than electronic mediums, but they are also highly valued. When managers arrange periodical, but informal, face-to-face time with their employees, this casual human contact is based on mutual respect and symmetrical dialogue, and can be very productive for teambuilding. It is also the richest communication medium, as it includes all non-verbal communication cues. Face-to-face conversations are perceived as more trustworthy and seen to increase employees' information satisfaction. Communication occurs in real time and provides immediate feedback, while contributing to a sense of community at the workplace, which makes it especially popular during times of organizational uncertainty or turmoil. (White &al, 2010: 74,78,79; Kupritz and Cowell, 2011: 55,64,74)

Generally people want to receive confidential or personal information face-to-face, while e-mail is preferred for critical and non-confidential information related to work duties, especially when arranging face-to-face meetings is not possible within the required time frame. (Kupritz and Cowell, 2011: 72-73)

Electronic communication

Over the last decades, Computer-mediated communication (CMC) has developed rapidly as electronic communication technologies (e-mail, internet, video conferencing, etc.) have blended in with the traditional face-to-face or fixed telephone communication channels in organizations. The rise of CMC has also had an effect on how people are increasingly being managed through electronic interaction, as opposed to the traditional face-to-face method, which is not necessarily a good thing as it poses a risk for dehumanizing this interaction. (Kupritz and Cowell, 2011: 55)

With geographically distributed organizations like the company, CMC is the obvious choice due to low costs and convenience. Interestingly, workers do not necessarily choose electronic communication for these same reasons, but simply because they are using computers most of the time on a routine basis anyway. Taking advantage of CMC is a technical opportunity to help companies communicate more efficiently, but implementing and integrating the correct technologies to fit with the existing organizational requirements and existing structures is not always an easy task. (Kupritz and Cowell, 2011: 56)

While the amount of data available has increased exponentially with electronic communication, the ability to interpret it properly has diminished, leading to increased misinterpretation and miscommunication. When managed properly, CMC has good return on technology investment, as it enables global real time communication and maintaining shared information reserves, ultimately a tool that helps manage time in order to enhance productivity. However, if not managed correctly, CMC can actually hinder productivity due to time spent on managing constant information overload and processing irrelevant data, while ignoring the relevant e-mails and struggling with all the multitasking and multi-communication that ensues. This emphasizes the importance of organizations continually evaluating the effectiveness of their communication channels so that they are value adding. In practice, this means identifying the most effective communication channels and the specific types of messages that need to be relayed. Consequently, companies should not forget the importance of traditional face-to-face communication when implementing CMC. (Kupritz and Cowell, 2011: 56-57, 74-75; Stainback, 2012: 33)

Despite the overload of messages, employees generally prefer e-mail as an information medium. E-mail is easy, cheap and fast to send. However, e-mail is very impersonal and limited to visual cues as it lacks all the intuitive, non-verbal cues that are present in normal human interaction during a face-to-face conversation. Other electronic mediums like video conferencing may have a higher “social presence”, as people feel that the other participants are physically more present. Discussions on e-mail do not progress in real time, which is not very practical when trying to explain complicated matters, pitching ideas, convincing people on something, or simply trying to get some feedback. E-mails tend to work best when they are used for quick notices to inform a larger group of people about the same thing, keeping people aware of updates on something they are already involved with, or when dealing with a geographically distributed group of people. (White &al, 2010: 70, 78; Kupritz and Cowell, 2011: 55, 58)

Another problem with e-mail is the sheer amount of messages, when it is generally the most obvious and popular medium for communication. This leads to potential loss of information as practically all e-mail users develop a personal filtering system where most messages are sorted, prioritized or even deleted based on quickly scanning the sender, the subject or some other surface detail as opposed to reading the actual message. (White &al, 2010: 74)

Like in many other companies, e-mail is widely used at the company to communicate critical messages to operators on processes and workflow, which is risky, and all the more reason to increase communication redundancy via alternative communication channels.

Intra -or extranets are another electronic medium that are often full of information and can be a good option to convey a lot of information to a large number of people as opposed to massive group e-mails. However, sometimes managers might use it as a communication medium and incorrectly assume that employees access it frequently. Though employees do value information stored on a webpage, they generally do not have much time to browse for information there. Employees tend to use the company webpage only as an archive where they can access specific information if they happen to need it. This is why managers may need to direct people via some other medium (face-to-face or e-mail) to the site when they want people to access specific information posted there. (White &al, 2010: 75, 81; Stainback, 2012: 33)

If electronic communication is utilized correctly, it has the potential to eliminate the traditional hierarchical structure of internal communication, where information flows from the top to the bottom, and is filtered and distorted in the process. With e-mail, specific employees or groups of people can be targeted at the same time as information can be sent directly between different organizational levels. (White &al, 2010: 81)

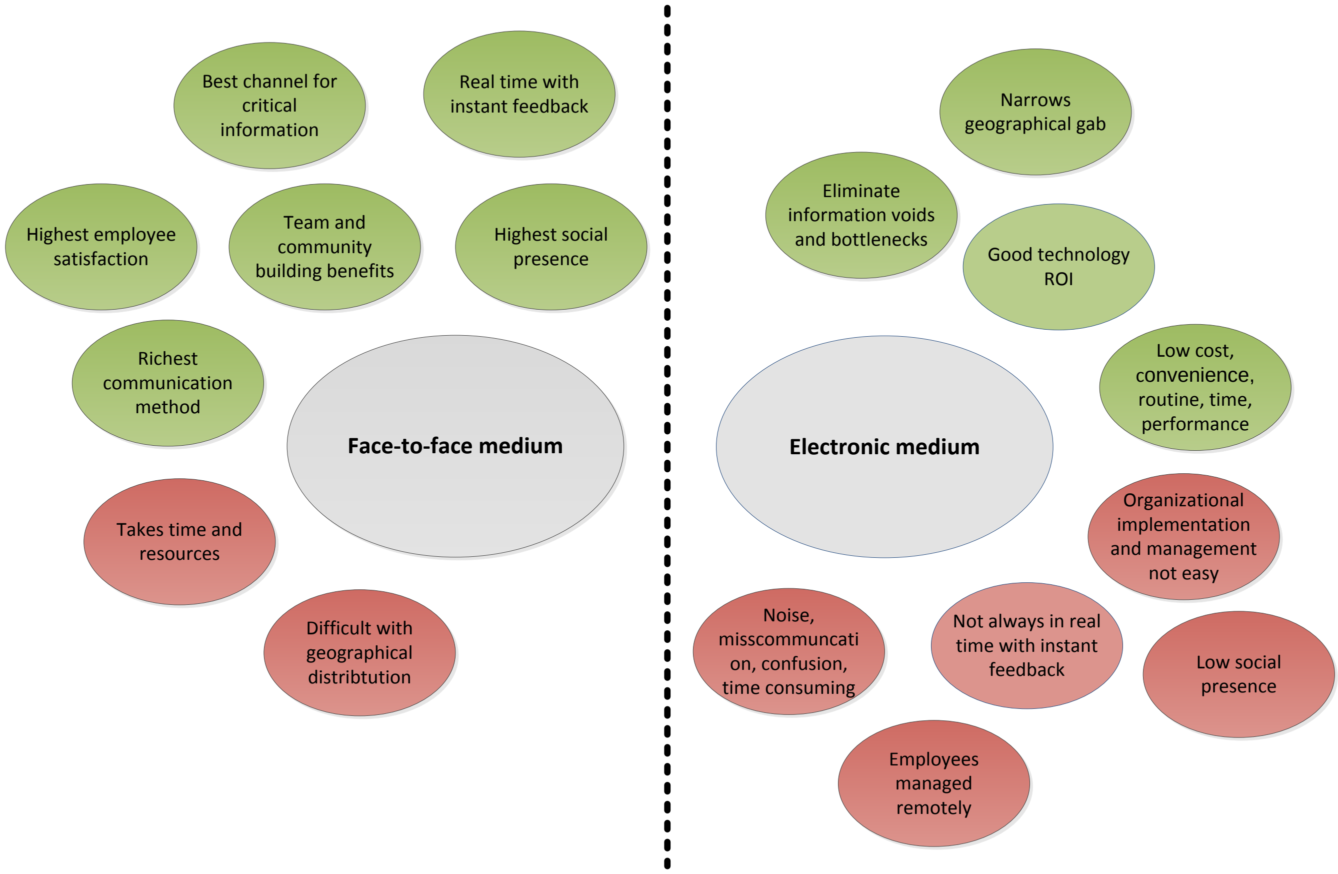

Figure 16. Perks (green) and cons (red) for face-to-face and electronic communication.

Conclusions

Efficient internal communication has a direct impact on employee satisfaction. Communication is dependent not only on the communication mediums selected and emphasized, but it is also affected by the level of organizational openness and trust that exists within the company.

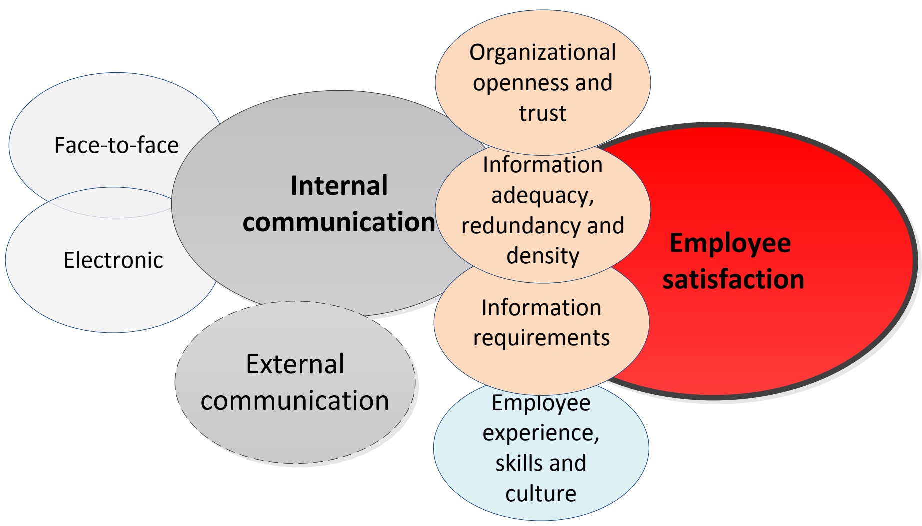

Figure 17. Factors affecting communication efficiency – overview

It is also important to manage communication density, bottlenecks and redundancy when ensuring internal communication is efficient. Consequently, information requirements vary from people to people based on their background and culture, which is why individual employee's information requirements vary accordingly.

4.3 Theme 3 - Employee training

Effective training increases both personal and business productivity as well as performance, growth and operational efficiency. Training differs from education, which is about acquisition of knowledge, while training is all about systematically developing new (or enhancing existing) skills based on measurable objectives aiming at observable change in trainees' behaviour and performance. Often the two are intertwined as knowledge must first be acquired before new skills can be applied. (Wagonhurst, 2002: 77, 79; Schraeder, 2009: 133; Lingham&al, 2006: 335)

Two important forces behind training requirements are changes in technology and a better educated workforce. Training must provide the employees skills that they need to utilize new technology in the workplace, which should ultimately result in lower costs, better quality, faster return on investment, and growth. This is why training must be not only cost effective, but also well aligned with corporate goals. (Derouen and Kleiner, 1994: 13; Kerri, 1998: 82)

Training based on needs assessment

The first thing to consider when setting up a training program is, which factors are affecting training effectiveness. Namely, what are the skills the employees need in order for the company to be competitive and successful through a competent workforce? Identifying training requirements takes time and resources, and it must be conducted by professionals, generally subject matter experts (SME), who may act as trainers as well, but should at least help understand the most important training requirements, since they are experts on the field about to be trained. Training subjects should be based on a "task analysis" that can be performed through interviews and questionnaires at different employee levels, while concentrating on current and estimated future performance requirements for different tasks in terms of time, cost and error rate. In practise, the target group employees should estimate for example task difficulty, performance, and training requirements, but also available organizational support, communication and feedback. (Wagonhurst, 2002: 77; Derouen and Kleiner, 1994: 13; Messmer, 2001: 8; Kerri, 1998: 83; Wakefield, 2012: 54)

Another important part of a need assessment is “skill assessment”, where existing collective experience and skills of the workforce are defined, while identifying opportunities for skills enhancement. It is suggested that employees should be treated as internal customers when taking steps to develop their competence through training, which is something employees are naturally inclined to participate in as they seek for professional advancement. Consequently, the level of internal “customer service” and support in training should at least match, if not exceed, the level of actual customer service. This kind of training augmentation aims not only at meeting, but exceeding, the trainee’s expectations. (Messmer, 2001: 8; Schraeder, 2009: 134; Kerri, 1998: 83).

Training needs assessment for the company has now been performed by an “SME” (the author) via the questionnaire study, which does indicate clear training requirements in certain areas. Current operator experience and skill levels are fairly well recognized within the company, as the operational team is still a fairly small and tightknit group. However, since mapping out operator skills, background and expectations are intertwined with Themes 1 and 2, where they are equally highlighted, it is something that should probably be considered for current and future operators.

Training methodologies

After the needs assessment, one should have a clear understanding on target group requirements and existing experience, which is something creative trainers tend to build upon. Training goals should also be reviewed at this point in order to make sure they match the reality. Ultimately, there are many training methodologies to choose from, but the underlying rationale should be based on achieving training objectives as cost effectively as possible, which is dependent on the amount of resources and time allocated for the training program. While training goals and selected methodologies are important, they should never be set in stone and training should also be flexible and as trainee oriented as possible. Training content should be tailor-made based on the collective pre-training needs and skills assessment, while it should also be possible to adjust content and schedules on the go based on trainee input during training. (Schraeder, 2009: 134; Kerri, 1998: 84,87; Bixby, 2012: 62).

While adults are generally voluntary students, they have their main work duties to handle on the side while training takes place, so their time is precious and their motivation will disappear rapidly if they feel training is not beneficial for them. Consequently, employee attitude is the biggest inhibitor or activator for learning, which is why it is important to take existing employee schedules into account and aim for flexible and supportive training programs, while emphasizing the importance of training for employee's professional development and team benefits. It is also suggested that training is more efficient when it is continuous and presented in segments of moderate length, few hours at a time, as opposed to a whole day. However, if training is too infrequent, for example one hour per week as opposed to several hours, learning is no longer continuous and trainees are likely to forget what they have learned or may lose interest altogether. (Wagonhurst, 2002: 79; Messmer, 2001: 8-9; Schraeder, 2009: 134-135; Kerri, 1998: 86; Bixby, 2012: 63)

This is something that relates to the company's outsourced operator training quite well, as external operators may have too infrequent training and exposure to the system.

Training commonly focuses on adult learners who differ in their learning styles and abilities. Traditional training has been fairly passive, classroom or instructor oriented, where the interaction between trainee and instructor is limited. It is a fairly cost-effective and familiar method for many trainees as they have been exposed to this teaching method in the past. However, lectures are generally the worst methodology for adult learners and it is difficult to build interaction, especially if doing technical training as subjects are highly technical. A combination of visual, auditory, interactive and self-directed methodologies is seen to work best as adults have different learning styles. The majority of adults still learn best through being actively engaged, and they also like to learn and share information that has a practical use for real life problems that they have encountered. Utilizing this collective wisdom is especially beneficial when training groups of adults with mixed experiences on different subjects. (Wagonhurst, 2002: 79-80; Derouen and Kleiner, 1994: 13; Messmer, 2001: 8-9; Schraeder, 2009: 134-135; Kerri, 1998: 84; Wakefield, 2012: 54)

The training materials that are used in the knowledge transfer must also maintain a high level of professionalism and credibility, while being easily approachable by avoiding technical jargon. Written materials should ideally be distributed in advance so trainees know what to expect and can focus on learning instead of taking notes. As mentioned before, passive lectures, video tapes and presentations are not best suited for adult training, though they do still provide a consistent way to share basic knowledge and demonstrate skills before continuing with more active methods. After knowledge has been transferred, it should immediately be reinforced with activities that directly relate to the intended objectives of the training session, for example assignments and exercises that help subjects get more involved. Interpersonal interaction in groups should be especially emphasized as an active methodology, as the collective wisdom of the group can be utilized in the learning process. Other active methodologies include problem solving, exercises, role play and simulation that enable participants to truly grasp, practise and develop their new skills acquired from the training (Wagonhurst, 2002: 80; Schraeder, 2009: 135-136; Kerri, 1998: 85)

Therefore, training is more efficient when trainees are given a change to reinforce knowledge transfer via direct hands-on experimentation while they are still learning. This way they are not limited by the instructor, but are able to utilize their existing experience and own rationale. The instructor is essentially constructing new knowledge as opposed to inserting it. Learning is often caused by the brains tendency to avoid repeating the same mistakes, which is why the trainees should also be allowed to make mistakes while they are experimenting with what they are only just learning. Here the challenge seems to be creating a safe setting to make mistakes, which is why simulation is the suggested methodology. (Bixby, 2012: 63)

All of this applies to operator training quite well. Interactive and group based methods, namely system simulation, seem especially efficient for this type of training where the instructor’s role would essentially be limited to providing basic knowledge and feedback, while operators would experiment and learn in a safe environment.

It is widely recognized that peers have a beneficial impact on learning, as it is often easier to learn together through conversations, joint exercises and other interactions. Sometimes there are no official trainers at all and experienced employees train each other on their individual, but separate duties. This kind of learning may also incorporate training that extends beyond an employee’s designated job description and main expertise, and focuses on other areas that their colleagues are working on, which will increase the overall expertise within the company. This kind of learning can be especially efficient in what is called “action learning”, which is a training methodology especially suited for situations that call for practical and realistic learning. In “action learning” all training is based on real problems faced by the company, while trainees are encouraged to venture outside their normal job description and work as a group to solve these problems. This kind of training is heavily product and process oriented, which makes it especially suited for operational training. (Schraeder, 2009: 136; Derouen and Kleiner, 1994: 14-16)

If the developer and customer are co-operating in product development, they may also be working together in the design and implementation of a training program. This is not only a cost-effective way to perform training, but also beneficial for product development as new and creative design ideas may emerge, increasing both developer and customer satisfaction. (Derouen and Kleiner, 1994: 14)

All of this again highlights the importance of simulator type training for the company, as operators could teach each other, while this could also be extended to cover developers training operators or vice versa, which would be an extension of operator involvement in product development that was discussed on Theme 1.

A common way to perform training cost-effectively is to ensure accelerated learning, where training is performed within a short amount of time and new knowledge and skills are adapted at an increasing rate. In order to achieve this it is important to remain positive and supportive. One should also try to strive for a “state of relaxed alertness” by arranging a comfortable and conducive training setting and workflow that increases motivation, while reducing stress and other barriers for learning. Arranging group based learning, while accommodating different learning speeds of the individuals involved, is also highlighted in accelerated learning, which is all about collaboration as opposed to competition. (Derouen and Kleiner, 1994: 15; Schraeder, 2009: 135)

This kind of action learning may also apply to new operator training at the company, but since live operations introduce a high level of stress for operators, at some point they should also learn to cope in stressful situations.

Training as a continuous and iterative process

The success of a training program is ultimately dependent on the amount of knowledge and skills that trainees are able to transfer into their work environment. Applying learned skills to actual work is when true learning takes place, which is why the efficiency of training programs is often difficult to assess, as learning is subjective and hard to quantify and estimate. However, it is still important to develop a long-term strategy for monitoring and evaluating the success of each training program in order to improve future training programs. One way to estimate training efficiency is to give tests before and after a training program, or to start evaluating trainees' work performance after the training. Another way is to acquire direct feedback from the trainees on how relevant and efficient they feel the program has been. This feedback should revolve around estimating how meaningful and applicable the training content and methodology is from an organizational and individual employee perspective. This feedback is especially important when planning for future training programs and assessing alternative training methodologies and topics. Therefore, it is suggested that one-off training programs do not have much of an impact, and training should be a chain of iterative programs that are revised based on the needs of the organization and individual employees through constant feedback from both stakeholders. (Wagonhurst, 2002: 80; Messmer, 2001: 10; Lingham&al, 2006: 335-336, 346; Kerri, 1998: 82, 87)

A closer look at simulator training programs

It seems that simulation is something that could be utilized very well with operator training, which is why setting up simulator training programs deserves a closer look.

Orchestrated immersion is seen as a very efficient way to envelop trainees in various interactive and immersive learning experiences. This is why simulators should be immersive and resemble the real system as accurately as possible and with the same dynamics as the live process. Developing a simulator may take time and resources, but it is also a very realistic, versatile and interactive training tool for continuous learning that could potentially be scaled up and made available also as an online tool accessible from anywhere. (Derouen and Kleiner, 1994: 15; Roe and Mason, 2010: 1; Kerri, 1998: 86; Roe and Mason, 2010: 3)

Simulators really bring training into life by enabling real-life situations re-enacted as virtual games or “scenarios”. Simulators can run what are perceived as “normal” conditions, but they are especially powerful when simulating “abnormal” conditions that can be triggered so that appropriate operator responses can be tested. These kind of problematic emergency situations really stress operator skills, knowledge and reflexes and without a simulator they cannot be sufficiently trained unless somehow faced in practise. These kinds of situations may include hardware or software malfunctions and bypass procedures. Operators may already know what to do in an abnormal situation, but identifying the problem and determining the appropriate response within the required time frame requires hands-on experience and practise on the issue. A simulator is a safe environment for gaining this experience and to practise in different conditions with different problem cases, which will make operators better prepared to handle these situations in a real-life environment under much more stress and a smaller margin for error. (Kerri, 1998: 86; Roe and Mason, 2010: 1,3)

Once a simulator training program has been set up and developed, it also needs to be maintained and managed in the long term. Simulators need to be kept up-to-date with the live system, but not only in terms of technology and workflow, but also updated with latest problem cases experienced at the field, so these can be added to the ever expanding simulator training program curriculum. (Roe and Mason, 2010: 4)

Cognitive task analysis

Traditional master-apprentice learning is based on skill acquisition from observation, followed by imitation, as supervision is gradually decreased, and finally culminating in totally independent performance. Trainees are not experienced so every step in the workflow takes conscious effort, whereas experts perform steps much more fluently with little or no conscious effort due to automation. The downside is that experts have difficulties in explaining the tasks that their brain has gradually automated, and they cannot necessarily identify each point in the process where decisions have to be made. This hinders teaching, as experts have difficulties communicating certain aspects of the workflow to the trainees. This is also one aspect where simulators can complement traditional training, as they can help identify moments and points where key decisions are made. (Tjiam &al, 2012: 698-699)

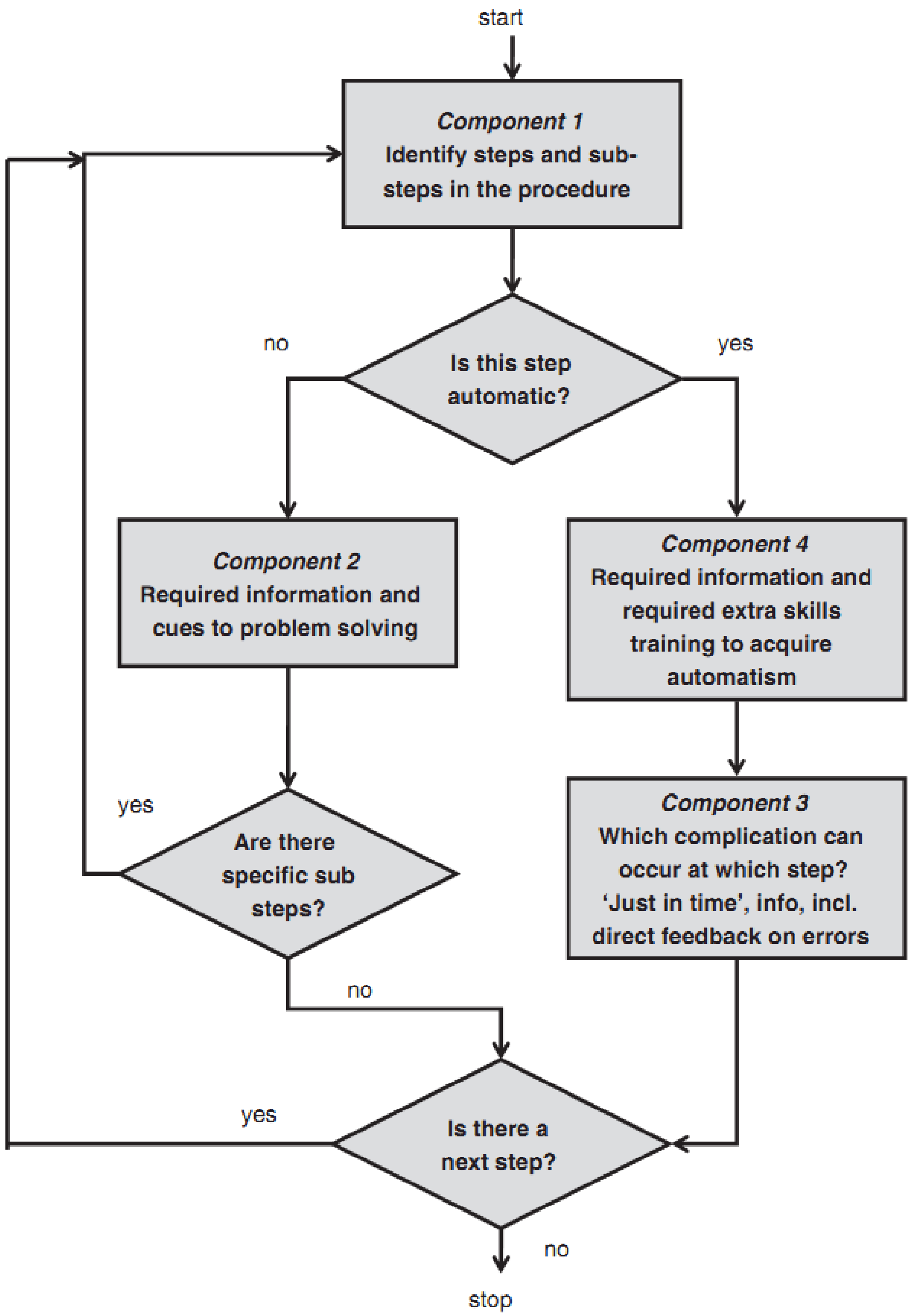

Figure 18. CTA analysis flowchart (Tjiam &al, 2012: 701)

Identifying when and how experts make automatic and unconscious decisions can be analyzed with what is called "cognitive task analysis" (CTA), as seen in figure 18. CTA is a good tool when defining simulator scenarios and breaking down different simulated tasks into a clear expected workflow. CTA analysis will find out which steps are automated on experienced users and what would be their automatic, unconscious response for each step. This provides not only technical details on how to best perform these steps, but also cognitive information on how experts would automatically perform a given task and instinctively react to any abnormal situations (problem cases), and what kind of supportive training would be recommended for trainees to reach expert level "automatism" faster. (Tjiam &al, 2012: 698-699,705)

4 C/ID model

This model is one of the most popular instructional design models, and it is aimed at creating task based training scenarios for different trainee levels. The model is divided into four components: scenarios, supportive information, JIT (feedback) information and part-task practice. (Tjiam &al, 2012: 700)

In this model, scenarios are different tasks with increasing difficulty levels, while supportive information refers to the knowledge and skills that need to be attained through training and instructions in order to complete the task. Supportive information is divided into three parts; descriptive theoretical information, prescriptive information about problem solving, and cognitive feedback that helps the trainee reflect upon the quality of their acquired theoretical knowledge. JIT information is direct real-time feedback (error messages) to the user based on his actions. Part-time practice is about supportive training for tasks that have to be trained for a high level of automation, characteristic for expert level users. (Tjiam &al, 2012: 700)

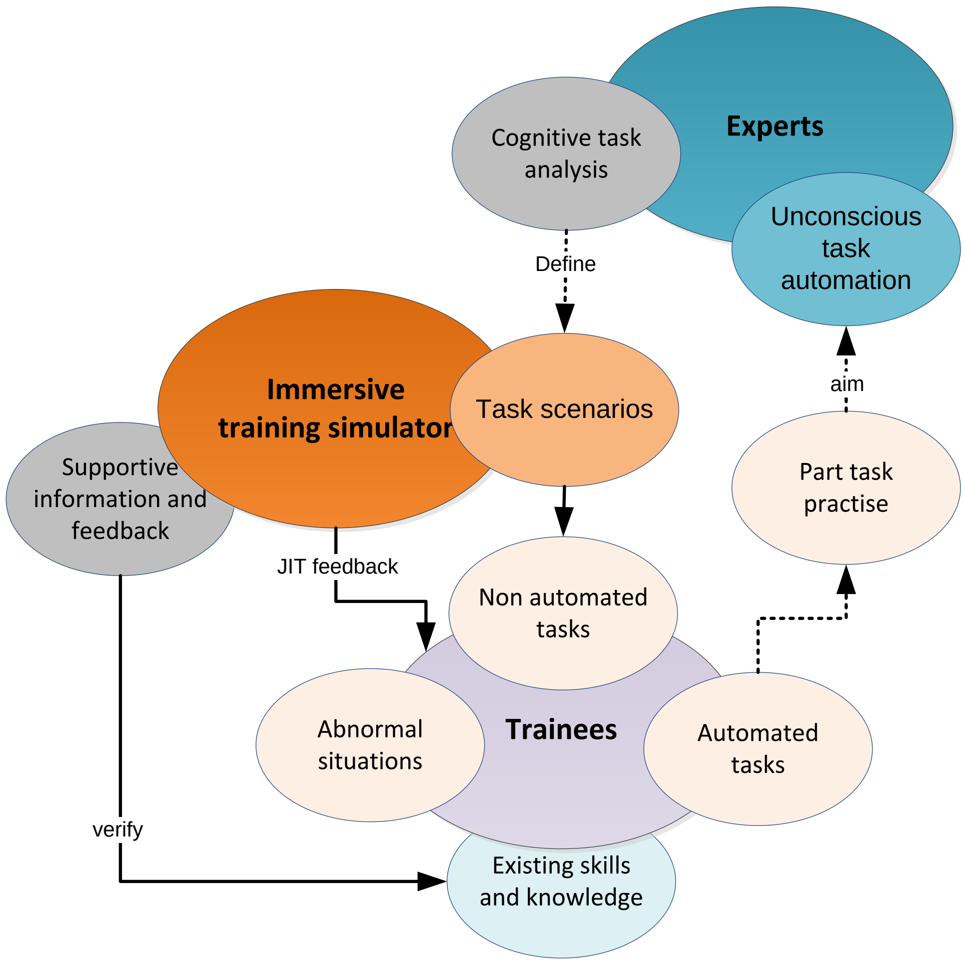

Figure 19. System simulator based on 4 C/ID model and CTA analysis

The 4 C/ID model and CAT analysis have been combined into a blueprint (Tjiam &al, 2012: 703) for simulator based training, and this blueprint will later on be utilized in the action plan for simulator training.

Conclusions

Employee training is intended to increase overall productivity, and it is all about setting up clear objectives based on a thorough needs assessment, after which cost effective training methodologies must be selected.

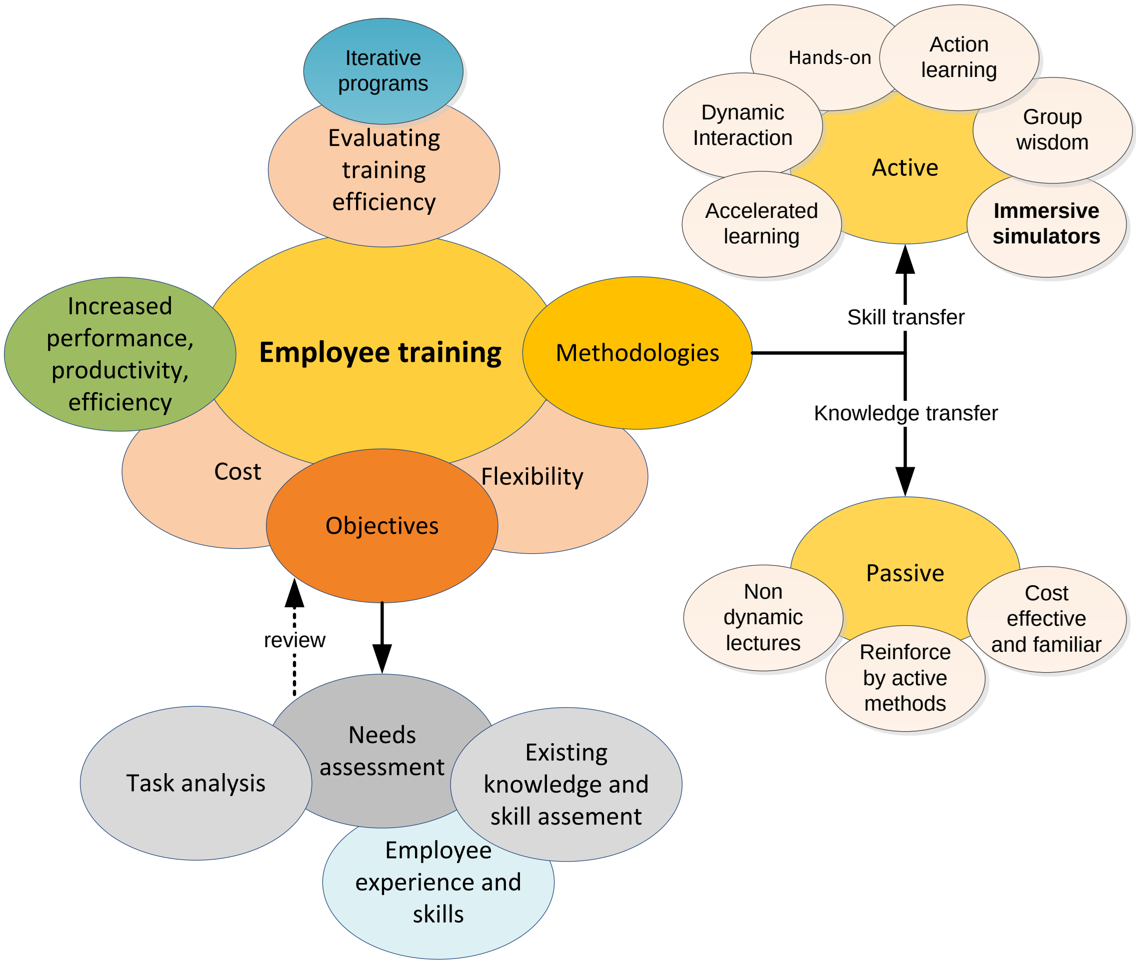

Figure 20. Factors affecting Employee training - overview

Passive methodologies are better suited for initial knowledge transfer, whereas active and more interactive methods truly enforce skill transfer and application into a real working environment. Finally, it is important to develop a long-term training strategy, where training programs are constantly evaluated and developed through an iterative process.

4.4 Conceptual framework

Based on the literary analysis it can be argued that operational scalability is heavily dependent on fulfilling end-user satisfactions, while developer satisfactions should also be taken into consideration. This fact applies to all of the themes that were analysed, starting from moderate end-user involvement in all aspects of system development (Themes 1 and 4), to organizational support in the form of efficient communication (Theme 2). Furthermore, targeted training programs (Theme 3) also play an important role in ensuring employee satisfaction.

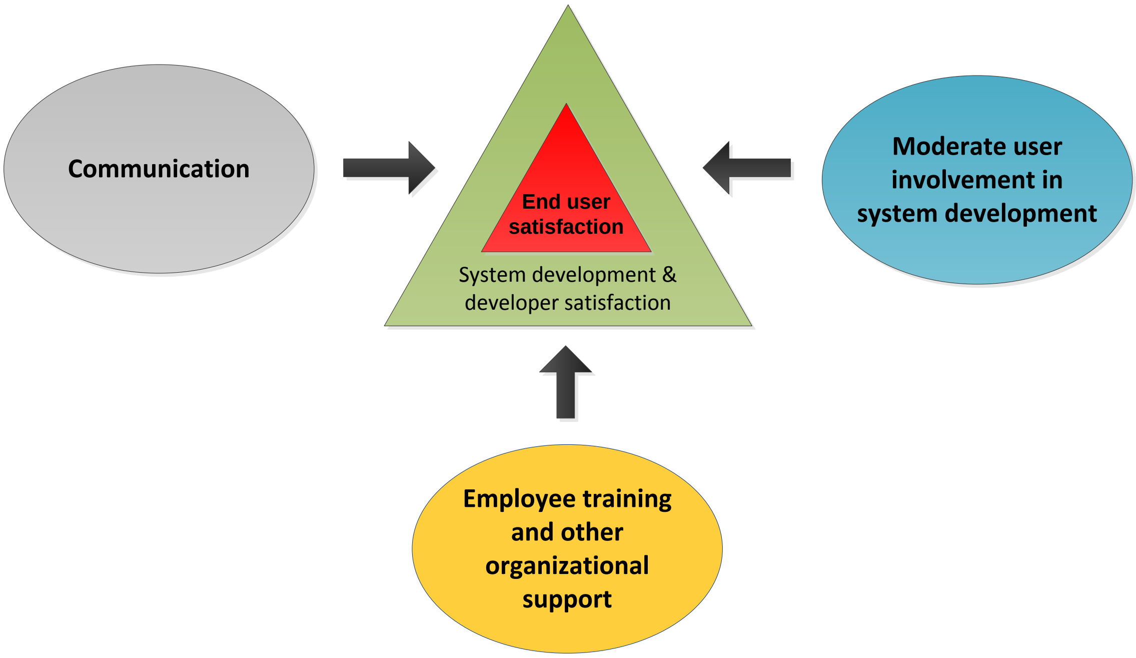

Figure 22. Conceptual framework - simplified overview

Perhaps not surprisingly, all of the themes emerging from the study seem to overlap considerably. Communication affects all areas and themes, while system development requires end-user involvement and benefits from organizational support and efficient training programs. Mapping out and recognizing end-user skills, experience and expectations is especially highlighted with all themes, which is an encouraging finding as this is what the questionnaire study and ultimately the whole Thesis project was mainly about.

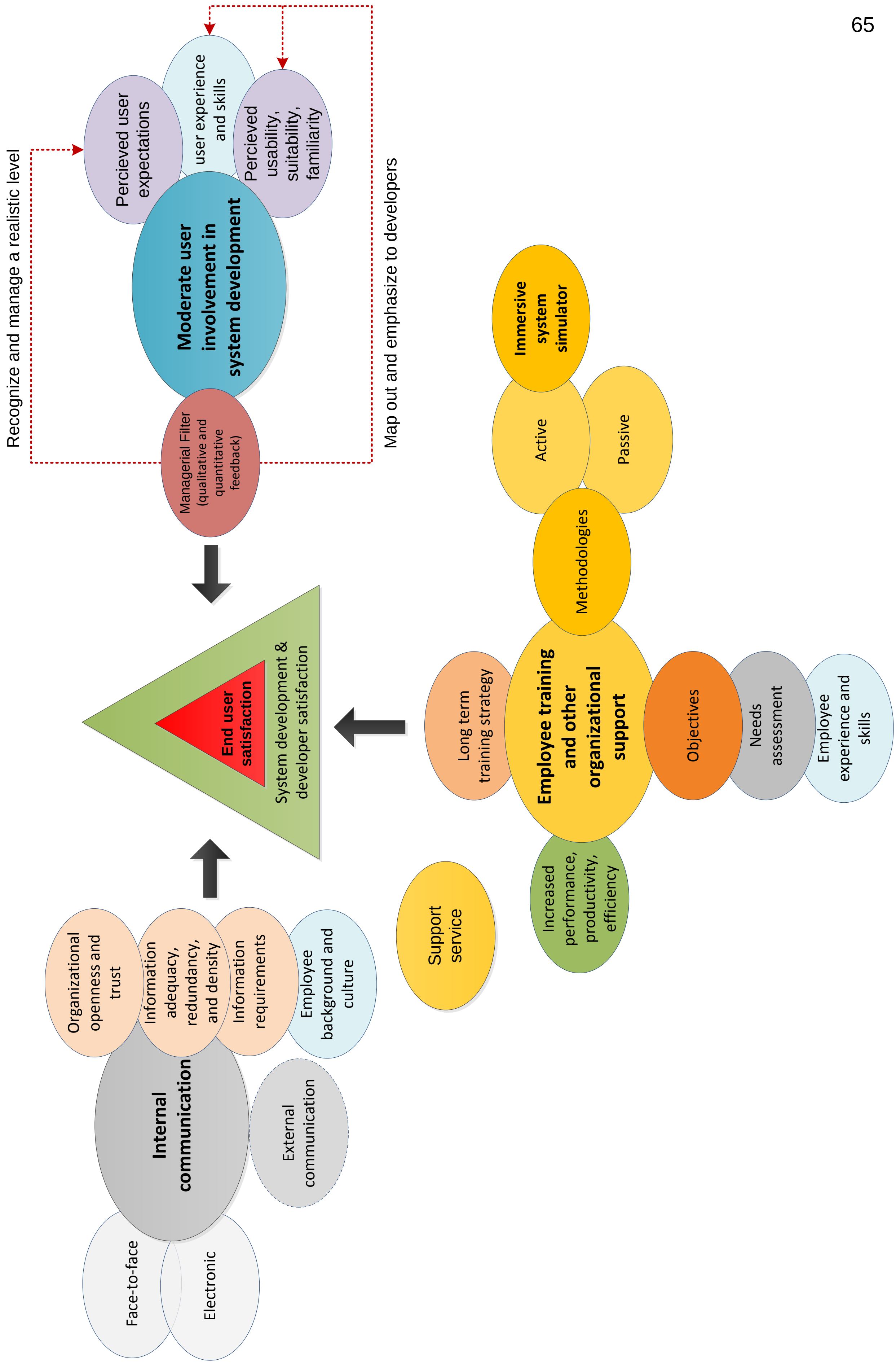

Figure 21. Conceptual framework - detailed

Next, this conceptual framework will be merged with findings from the current state analysis and an action plan for operational scalability will be presented.

5 Proposed action plan for operational scalability

In this chapter, ideas and strategies inspired by the questionnaire study and the related theoretical analysis are presented in the form of an action plan.

Please note that the proposed action points are only suggestions and may or may not be feasible to execute or develop further, which is ultimately for the management to decide, but this proposal should at least inspire development strategy in some way. Also note that the term "developer" refers to both R&D and operational developers or managers.

5.1 Theme 1 - Ensure system development meets operator expectations

This section presents ideas on how to ensure operator expectations are met in system development.

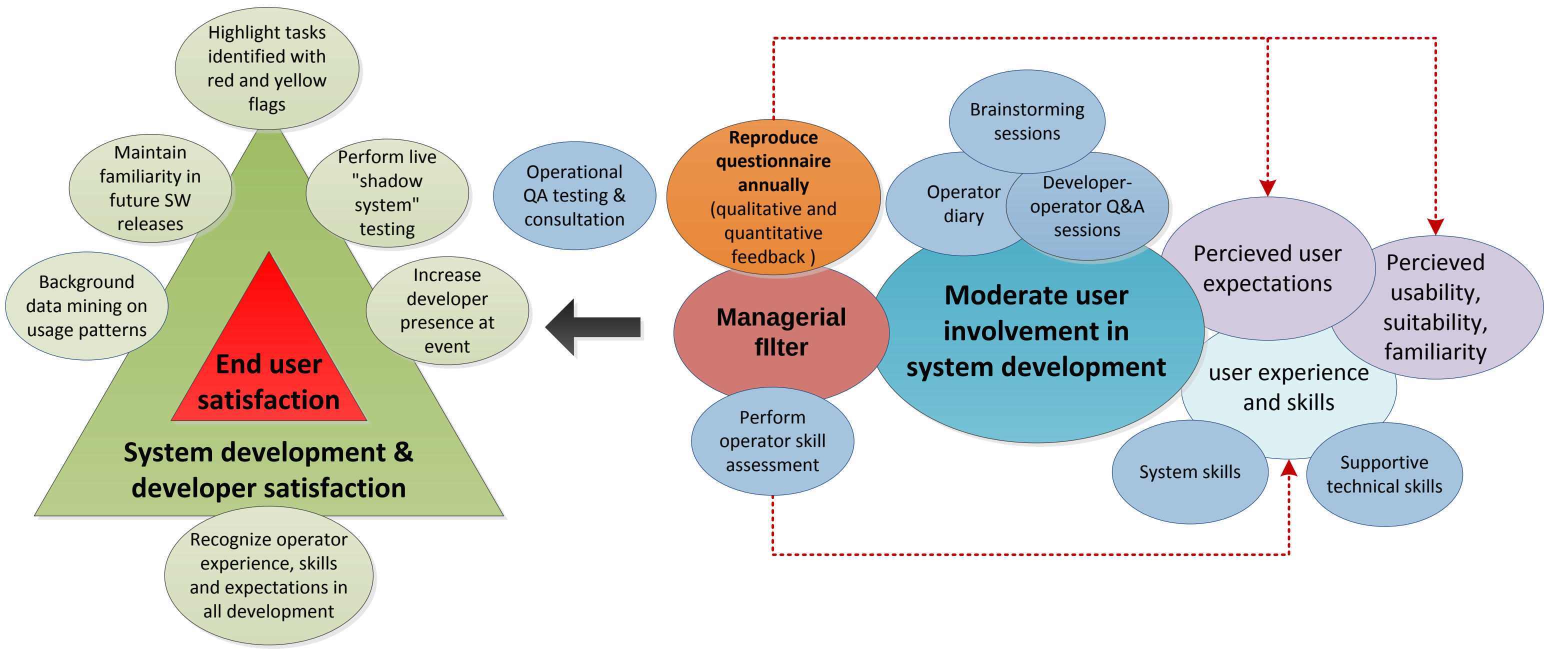

Figure 23. Action plan overview for Theme 1

Recognize operator experience, skill level and expectations in all system development and gradually prioritize increased usability

At the moment, system development is not yet prioritized towards meeting operator requirements, but for making the system work in difficult conditions by any means possible. In the near future development priorities are expected to gradually shift from making the system work in all conditions at the expense of general usability, towards making it easy to operate in all conditions.

Utilize questionnaire ratings and template in current and future development

Based on the study, several tasks were identified where operators (on average) rated one or more aspects of operational scalability (usability, training difficulty, operational risk, preferred development prioritization) more problematic than the developers.

Table 6. All tasks that have been assigned with red or yellow flag for developer's attention

Task	O-AVG	
1	**3.3**	
6.9	**3.2**	
6.1	**3.0**	
17	**3.0**	
18.1	**2.8**	
16.1	**2.7**	
7.1	**2.6**	
6.6	**2.6**	
9.5	**2.5**	
11.2	**2.4**	
6.2	**2.4**	
16.2	**2.4**	
3	**2.3**	
6.10	**2.2**	
10.6	**2.1**	
22.4	**1.8**	

Task	O-AVG	
11.7	**2.9**	
18.5	**2.8**	
18.3	**2.8**	
10.5	**2.8**	
22.5	**2.6**	
22.1	**2.6**	
2	**2.3**	
21	**2.2**	
13	**2.2**	
6.11	**2.1**	
4	**2.1**	
22.2	**2.1**	
14	**2.1**	
20	**2.0**	
7.3	**1.9**	
6.7	**1.9**	
12	**1.9**	
8.1	**1.8**	
22.7	**1.5**	
22.9	**1.5**	
9.1	**1.4**	

In Table 6 above, the average operator rating for all questions (i.e. operational scalability) is displayed for all tasks that have either a red or yellow flag on one or more questions. All these tasks are in need of increased developer attention.

Table 6. Task severity rated over 2 by operators, categorized for each question

	Q1 - System usability		
	ops	dev	
Task	Q1 AVG	Q1 AVG	ΔQ1
6.9	3.1	2.3	-0.8
1	3.1	2.3	-0.8
6.1	3.0	2.3	-0.7
11.5	3.0	4.0	1.0
11.3	2.9	3.4	0.5
18.7	2.8	3.6	0.8
18.4	2.7	3.7	1.0
11.4	2.6	3.6	1.0
11.7	2.6	3.3	0.7
18.3	2.6	3.3	0.7
18.1	2.6	2.6	0.0
18.5	2.6	2.7	0.1
9.5	2.5	3.0	0.5
11.1	2.5	3.3	0.8
10.5	2.4	2.7	0.3
18.2	2.4	3.7	1.3
18.6	2.4	3.5	1.1
22.1	2.4	2.3	-0.1
10.3	2.3	2.5	0.2
16.1	2.3	2.3	0.0
22.5	2.3	2.3	0.0
6.2	2.3	1.3	-1.0
6.6	2.3	2.8	0.5
10.10	2.3	3.0	0.7
21	2.2	1.8	-0.4
14	2.2	2.0	-0.2
15	2.2	3.8	1.6
16.2	2.2	2.2	0.0
2	2.1	1.8	-0.3
6.5	2.1	3.3	1.2
10.6	2.1	1.8	-0.3
11.6	2.1	2.4	0.3
13	2.1	2.0	-0.1
17	2.1	2.4	0.3
3	2.1	1.8	-0.3
10.2	2.1	2.6	0.5

	Q1.1 - training difficulty		
	ops	dev	
Task	Q1.1 AVG	Q1.1 AVG	ΔQ1
11.4	3.3	4.1	0.8
18.7	3.3	3.7	0.4
17	3.1	2.4	-0.7
11.5	3.0	4.1	1.1
18.2	3.0	3.9	0.9
18.3	3.0	2.8	-0.2
18.6	3.0	3.9	0.9
18.1	2.9	2.4	-0.5
10.10	2.9	3.0	0.1
8.3	2.8	3.0	0.2
11.1	2.8	3.7	0.9
6.6	2.7	3.0	0.3
11.3	2.7	3.6	0.9
11.7	2.7	3.5	0.8
18.4	2.7	3.7	1.0
18.5	2.7	2.3	-0.4
7.1	2.7	1.5	-1.2
16.1	2.7	2.8	0.1
10.5	2.6	2.3	-0.3
10.8	2.6	3.2	0.6
10.9	2.6	3.0	0.4
9.5	2.5	2.8	0.3
16.2	2.5	2.2	-0.3
6.2	2.4	1.0	-1.4
6.10	2.4	2.8	0.4
10.2	2.4	3.0	0.6
11.2	2.4	3.1	0.7
13	2.4	2.1	-0.3
15	2.3	3.6	1.3
6.4	2.3	2.8	0.5
6.5	2.3	3.0	0.7
6.11	2.3	3.0	0.7
10.6	2.3	1.8	-0.5
11.6	2.3	2.6	0.3
10.3	2.2	3.5	1.3
14	2.2	2.2	0.0
20	2.2	1.9	-0.3
6.3	2.1	2.2	0.1
10.4	2.1	2.4	0.3
12	2.1	2.0	-0.1

	Q2 - Operational risk		
	ops	dev	
Task	Q2 AVG	Q2 AVG	ΔQ2
1	3.3	2.0	-1.3
11.1	3.2	3.2	0.0
10.5	3.0	2.8	-0.2
11.4	3.0	4.0	1.0
6.1	2.9	2.0	-0.9
6.9	2.9	2.7	-0.2
11.5	2.9	3.6	0.7
17	2.9	2.9	0.0
16.1	2.8	2.3	-0.5
18.1	2.7	2.3	-0.4
18.2	2.7	3.0	0.3
11.3	2.7	2.9	0.2
7.1	2.7	2.0	-0.7
22.1	2.6	2.3	-0.3
11.7	2.6	2.3	-0.3
18.5	2.6	2.7	0.1
18.7	2.6	2.9	0.3
9.5	2.5	2.0	-0.5
2	2.4	2.0	-0.4
18.4	2.4	2.9	0.5
22.5	2.4	2.3	-0.1
10.4	2.4	2.4	0.0
11.6	2.4	2.9	0.5
3	2.3	1.8	-0.5
10.9	2.3	2.7	0.4
18.6	2.3	3.0	0.7
4	2.2	2.0	-0.2
15	2.2	3.2	1.0
16.2	2.2	2.2	0.0
6.2	2.1	2.0	-0.1
6.3	2.1	2.2	0.1
6.10	2.1	1.8	-0.3
10.2	2.1	3.1	1.0
10.6	2.1	1.5	-0.6
18.3	2.1	2.8	0.7

	Q3 - Preferred prioritization		
	ops	dev	
Task	Q3 AVG	Q3 AVG	ΔQ3
11.4	4.0	4.9	0.9
17	4.0	3.0	-1.0
11.3	3.9	4.0	0.1
11.5	3.7	4.4	0.7
11.7	3.7	3.3	-0.4
18.2	3.7	4.4	0.7
6.9	3.6	3.0	-0.6
11.2	3.6	2.6	-1.0
18.6	3.6	4.3	0.7
11.1	3.5	4.0	0.5
1	3.4	3.5	0.1
18.5	3.4	3.1	-0.3
18.7	3.4	3.7	0.3
6.6	3.3	1.7	-1.6
18.3	3.3	3.4	0.1
18.4	3.3	4.0	0.7
7.1	3.2	2.0	-1.2
11.6	3.1	3.1	0.0
22.5	3.1	3.0	-0.1
10.5	3.1	3.4	0.3
10.10	3.1	3.6	0.5
6.1	3.0	3.7	0.7
10.8	3.0	3.8	0.8
10.9	3.0	3.7	0.7
16.1	3.0	3.0	0.0
18.1	3.0	2.4	-0.6
6.3	2.9	3.2	0.3
22.2	2.7	2.3	-0.4
21	2.7	2.3	-0.4
22.1	2.7	2.3	-0.4
16.2	2.7	2.2	-0.5
6.2	2.6	3.0	0.4
6.10	2.6	1.8	-0.8
10.4	2.6	3.4	0.8
9.5	2.5	2.6	0.1
15	2.5	4.0	1.5
10.2	2.4	3.1	0.7
13	2.4	2.3	-0.1
3	2.4	4.3	1.9
4	2.3	2.4	0.1
7.3	2.3	3.5	1.2
2	2.3	3.4	1.1
6.11	2.3	2.2	-0.1
7.2	2.2	3.0	0.8
8.2	2.2	2.0	-0.2
14	2.2	2.2	0.0
22.8	2.2	2.5	0.3
6.7	2.1	1.8	-0.3
10.7	2.1	2.5	0.4
22.4	2.1	1.0	-1.1
22.3	2.1	2.7	0.6

	Operational scalability (Q-AVG)		
	ops	dev	
	O-AVG	D-AVG	
1	3.3	2.6	
11.4	3.2	4.2	
6.9	3.2	2.7	
11.5	3.1	4.0	
6.1	3.0	2.6	
11.1	3.0	3.5	
11.3	3.0	3.5	
17	3.0	2.7	
18.2	3.0	3.7	
18.7	3.0	3.5	
11.7	2.9	3.1	
18.5	2.8	2.7	
18.3	2.8	3.1	
18.6	2.8	3.7	
10.5	2.8	2.8	
18.1	2.8	2.4	
18.4	2.8	3.6	
16.1	2.7	2.6	
22.5	2.6	2.5	
6.6	2.6	2.5	
7.1	2.6	1.9	
22.1	2.6	2.3	
10.10	2.6	3.0	
9.5	2.5	2.6	
10.9	2.5	3.0	
11.6	2.5	2.8	
11.2	2.4	2.7	
6.2	2.4	1.8	
10.8	2.4	3.0	
16.2	2.4	2.2	
15	2.3	3.7	
3	2.3	2.6	
2	2.3	2.4	
6.3	2.3	2.5	
10.2	2.3	3.0	
10.4	2.3	2.7	
21	2.2	2.0	
6.10	2.2	2.2	
13	2.2	2.0	
6.11	2.1	2.5	
4	2.1	2.2	
10.6	2.1	1.8	
22.2	2.1	2.0	
14	2.1	2.1	
8.3	2.0	2.6	
20	2.0	2.0	
10.3	2.0	2.6	

In a more detailed table 7 above, all tasks that received an operator (severity) rating higher than 2 are displayed for each question on operational scalability. Developers should pay close attention to tasks where the developers' severity rating is much lower (red flags), but also look into tasks where developer ratings are slightly lower (yellow flags).

The questionnaire template should also be further developed and reproduced annually in order to gain qualitative and quantitative feedback on actual operator requirements and expectations without a managerial filter, and to monitor how well development meets those requirements.

Perform operator skill assessment

Operator experience and skill levels should be mapped out and highlighted to developers, as all development should ideally be based on end-user skill levels.

- Individual system operating skills and experience level for each operator can be found out through managerial estimation, testing and peer assessment. The questionnaire used in this study can also be further developed for estimating operator skill levels.
- Also chart supportive, non-system technical skills (IT, electronics, engineering, etc.) through operator interviews. This information will be useful when setting up technical training programs, defining recruitment qualifications or training new operators.

Aim at moderate operator involvement in system development

It is important to continue filtering operator feedback through operational managers, who are also system experts and therefore able to recognize valuable operator input from the irrelevant. However, it is also important to:

- Encourage operators to get more involved with informal brainstorming sessions while managing their expectations at a realistic level
- Have operators keep a diary on any questions that may arise at any time, and schedule monthly, informal "questions and answers" meetings between operators and developers where operator diary questions are answered
- Increase operational involvement in R&D Quality Assurance (QA) testing (see next point)

Increase operational support for QA testing

Incorporating consultation from operational system experts should ensure R&D QA testing methods are operationally as realistic as they can be in lab conditions. Also, any new software releases should be tested by operators in a more coherent and controlled manner.

- First, a clear (SW) release testing procedure and guide should be formulated in co-operation with operations and QA.
- Then any new release testing should be included in operational scheduling, and operators should test the new release following the test procedure and report to operational management and QA.
- Additional, supportive QA testing programs could also be scheduled for operators during the off-season when they are less busy with operational tasks.

Perform “shadow system” testing and training in parallel with a live broadcast

Assuming there is space in the OB, as well as available PCs and operators, it may be possible to perform either SW testing or training in parallel with, while still isolated from, the actual live broadcast. It may be worth assigning an additional OB van to the event and sending external R&D developers to run the “shadow system”, or utilizing a remote internet connection to OB PCs so live testing can be performed remotely.

Perform background data mining while operators operate the system

Automatically monitoring and logging operator actions might help find out how operators work, and behavioural patterns may begin to emerge, identifying common mistakes, tasks that could be automated, and triggers where better feedback is required from the SW.

Increase developer presence at events

Key developers should be more involved at events, but not only as support personnel like in the past, but also to learn about the actual system operating conditions.

Maintain relative compatibility in all future SW releases

Maintaining familiarity in all SW updates is important as it makes it easier for operators to adapt to changes.

5.2 Theme 2 - Improve communication

In this section, ideas on how to improve communication from an operational perspective are suggested.

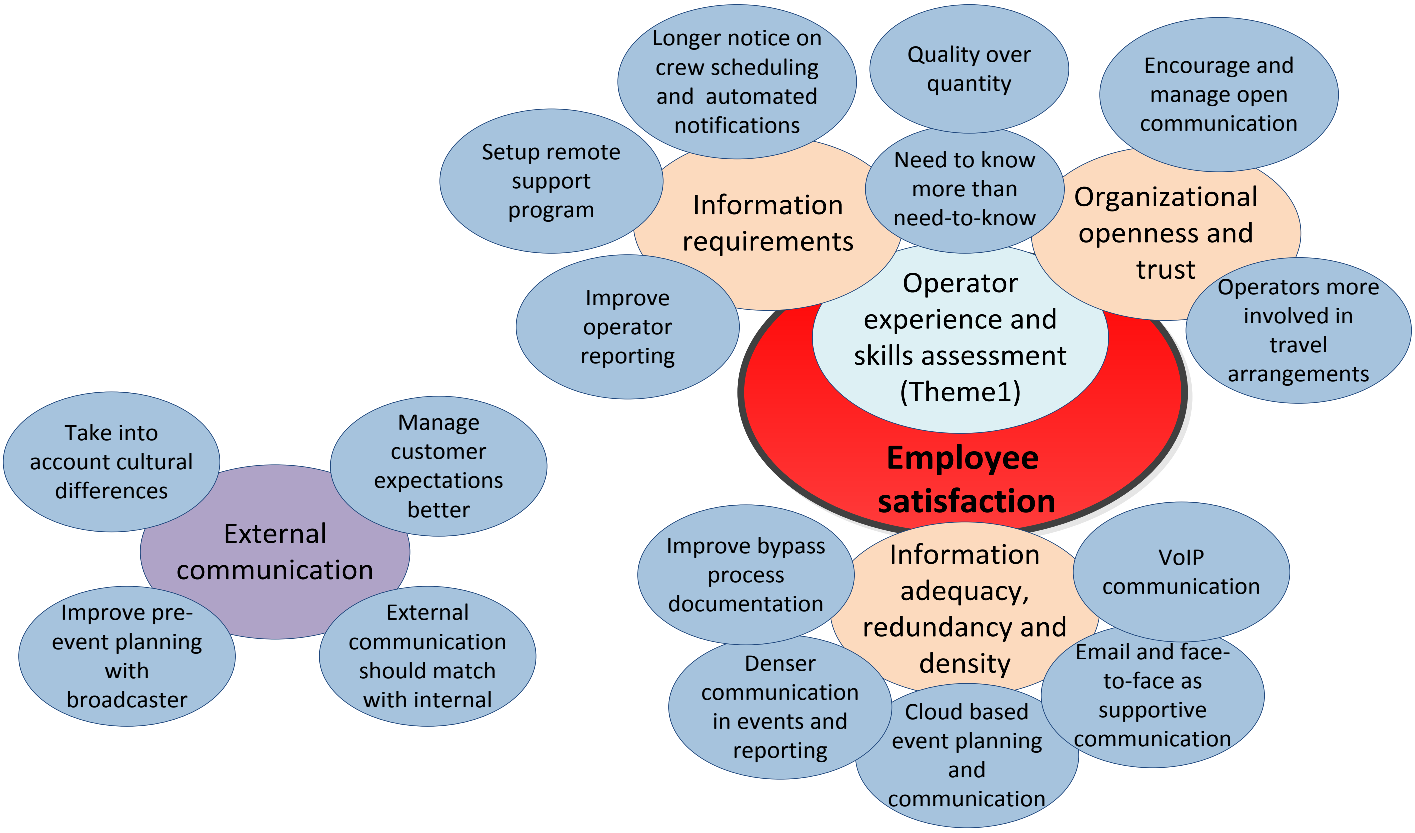

Figure 24. Action plan overview for Theme 2

General ways to improve communication

It is important to aim at organisational openness in all communication, while managing communication between operator and developer teams in order to avoid mixed messages. It is also imperative that internal communication to operators matches with all of the external communication to broadcasters, partners or customers in order to avoid mixed messages in field conditions.

Managers should recognize that operator information requirements are based on their skill and experience level (mapped out in Theme 1). Quality over quantity in manager-operator communication should be highlighted, while operators should be encouraged with access to more information than they absolutely “need-to-know”, especially if it is technical information.

Communication should also be “dense”, i.e. descriptive and detailed, and focused on the point. This applies to both on-site communication and event reports. Email should be used to communicate critical messages to operators on processes and workflow, but also alternative communication channels should be utilized (see next action point) in order to enforce and highlight the message as emails may easily go unnoticed. Setting up redundant communication channels makes all the difference when making sure operators are well informed on everything they need on the job. In practise, this can be alternative (electronic and face-to-face) communication methods between developers and operators, but also additional people enforcing the original message down the organizational chain.

Incorporate cloud based centralized event communication

All of the information that operators need leading to -and during an event should be concentrated and continuously updated in a centralized, cloud based system. This improves communication redundancy and reduces bottlenecks, risk and dependency on interpersonal communication and emails. Operators and developers should access all event information and perform all important event communication in the cloud system as opposed to email, and critical updates in the cloud should also trigger automatic email or SMS notifications to enforce the message.

In practise, the amount of information systems being used at the moment should be reduced and merged into **two** separate systems.

- *Focal Point* should still be used for crew scheduling, inventory and expenses, as it is already intertwined with H&R and financial asset management.
- *N: drive* should be discarded and email use minimized while *Basecamp* (or some alternative cloud based system) should be used for all event planning, discussion and documentation, such as:
    - Call sheets
    - Site surveys
    - Venue specific fibre installation route guide
    - Operational process guides
    - Event reports
    - Supportive technical documentation (OB diagrams, manuals)

Setup remote technical support program for events

Existing research suggests that “hidden costs” associated with time spent on solving operational problems on site can be as high as two-and-a-half times the known hardware and software cost in terms of productive operating time lost during the process. Therefore, setting up a remote support service for events is imperative not only from an operational point of view, but also from a financial perspective, as it seems like a surprisingly cost-effective solution.

- There should be on call personnel (either developers or operational experts) for every event and they should be compensated accordingly.
- It might also be viable to set up a remote desktop connection to the system PCs at the OB van. This way, remote support personnel would have direct and safe access to the live system PCs, which would make it easier to solve issues remotely.

Improve crew allocation and scheduling communication

Operators need a longer notice on future crew assignments, but also quicker, ideally automatic notifications, immediately when crew assignments are confirmed or cancelled.

Involve operators and Unit Managers more in travel arrangements

Operators need to be more involved in the booking process (flights, hotels, rental cars), and the Unit Manager should act as a first point of contact for all on-site travel related support.

Also improve external communication

This is emphasized in pre-event planning with the host broadcaster, specifically about integration workflow and schedule requirements.

- Take into account “low and high context” cultural differences. In Spain and Italy (high context) communication may be fairly implicit, while English/Finnish (low context) communication tends to be much more accurate and explicit.
- Improve on site instructions and documentation to be used with host broadcaster. Make sure all broadcast terminology matches with the host, and use a translator if required.

It is also important to communicate to the customer that digital ads should be non-disruptive and must look natural and blend in with the TV picture, even if it means compromising brand colours. Operators are not qualified vision engineers, and their primary concern is to make the ads look as realistic as possible. Above all, operators are not brand managers and ensuring the integrity of brand colours should never be their main concern.

Set up a process for a system FACS check

Before a live broadcast, approximately 30 minutes before losing control over the cameras, the operator team should check that the system is working well and ready for a live broadcast. If something needs to be fixed at this point, there should still be time to do it.

Improve bypass process documentation

Current documentation is a good starting point, but since it is only sample pictures with a written description of potential bypass scenarios, it has little value during a live broadcast, where operators make quick decisions instinctively based on experience and subjective evaluations on system output quality. There also seems to be confusion on whether bypass is operationally and commercially acceptable, especially when individual billboards are bypassed.

- Management should go through recorded matches and determine situations where bypass would have been acceptable or non-acceptable, and an archive of example videos should be generated and incorporated to current bypass process documentation.

Improve OB to Camera communication with a VoIP based talkback device

Radio connection is often poor, and host OB talkback connection to the cameras cannot always be setup before the system calibration and testing phase, when operators need it the most. The fibre connection between the OB and the camera bracket could be utilized for creating an additional communication channel.

- There is an Ethernet line in that is not currently utilized where VoIP (voice over IP) talkback HW could be used. IP based talkback is very cost effective after initial installation and could also be utilized in testing and training events when host OB or radios may not be available.

Improve operator reporting

During the event, operator notes could be taken more efficiently as problems occur and are solved in a rapid manner and little time is left for taking notes.

- A mobile phone application for voice recording could be utilized, so that quick notes could be dictated with mobile phones.

Also, operators do not have much time to reflect upon the event and encountered issues as a team immediately after the event is over and the whole experience is still fresh in their memory. The Team Leader generally writes the event report while other operators are de-rigging the system.

- Set up a quick meeting immediately after the event, so that all operators can review the Team leader's report draft and possible additions or corrections can be made collectively.

Post-event feedback to outsourced operators/riggers should also be improved, as it is pretty much non-existent at the moment.

5.3 Theme 3 - Improve training programs

In this section, ideas are presented for setting up training programs that are both directly and indirectly related to operating the system.

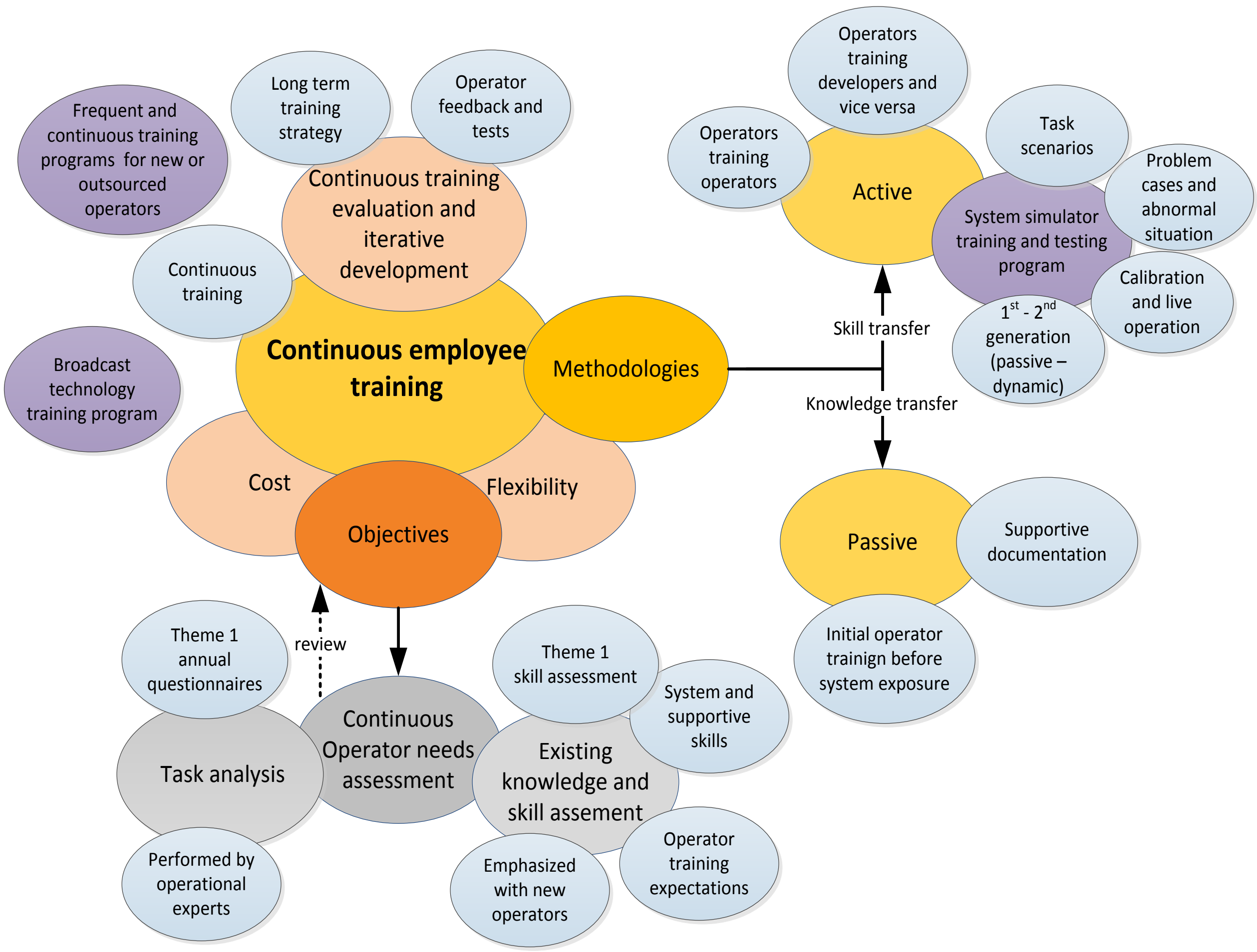

Figure 25. Action plan overview for Theme 3

Prior to starting any new training program

Any new program should be based upon a needs assessment performed by an operational expert:

- Training needs should be clearly mapped out and reproducing the questionnaire annually (see Theme 1) should help with this.
- Operator skills and experience on the system or supporting technologies should also be mapped out (see Theme 1), and this needs to be taken into consideration when planning training programs.
- Specific operator training expectations should also be taken into account.

Clear training goals should be formed and:

- Selected training methodologies should be cost effective, interactive and utilize the collective experience of the operator group.
- Traditional teaching methods for theoretical knowledge must precede all practical or interactive training and system exposure, whilst the latter should be emphasized.

After a training program

It is important to develop a long-term strategy, where the success of each training program is assessed through tests and trainee feedback. This helps to continuously update training programs for the future by reassessing training topics and methodologies based on a continuous operator needs assessment.

Utilize detailed task analysis for system training

Now that the operator workflow has been broken down into (73) specific tasks, this clearly defined workflow could be utilized in future operator training. All tasks are described in detail in the detailed task analysis found in Appendix 6, and this should be used as a basis for creating a manual on operator workflow.

Continuous training for new or outsourced operators

It is important to recognize that one-off training programs rarely have the desired effect. If new or outsourced system operators are to be trained, it is imperative to ensure frequent (weekly) training and exposure to the system. Existing research suggests that trainees should be trained or exposed to the system at least several hours per week or training is likely to be futile.

- Since outsourced operators are not based at the company's operational base, but in different countries, their system exposure is currently limited to infrequent training and real events, which are not always ideal for training. This is why the current outsourced operator training program needs to be enhanced with a system simulator, which trainees can operate independently or with limited remote support.

Improve operator training and system development with a system simulator
This is not only a very effective, scalable, interactive and group based method, but also a safe and realistic way to reinforce knowledge transfer from training.

- Simulator training is dynamic as it ranges from normal operation conditions to abnormal situations based on real life problems encountered at the field.
- The role of traditional trainers diminishes and is limited to basic training, where they provide basic knowledge and theory. Action learning is highlighted as operators switch roles between simulator administrators and operators, so they will learn both independently and from each other as a group.
- An operator could host simulator training programs for developers and vice versa, which would be very efficient for improving developer operator co-operation (Theme 1).
- A simulator is a stress free environment for new operator training, but ultimately stress simulation could also be incorporated.

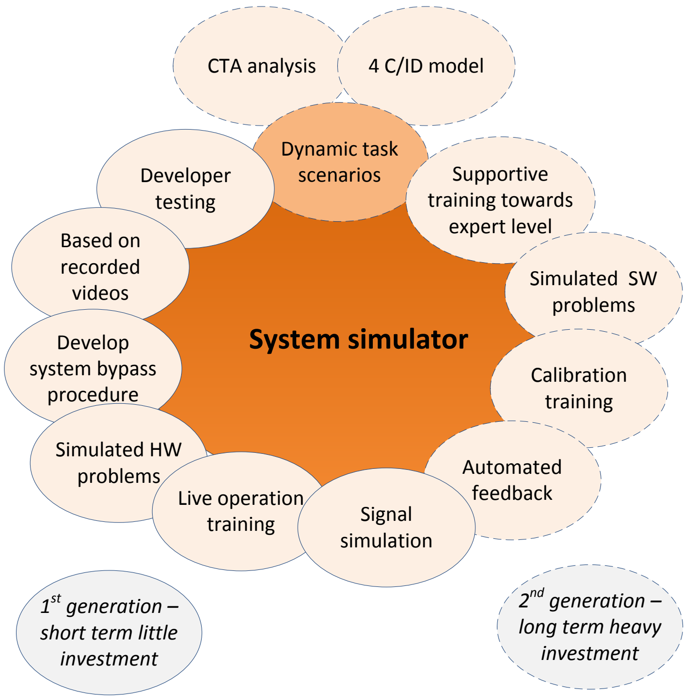

Figure 26. System simulator concept - overview

1st generation – passive signal simulator

The first generation simulator should simulate normal operations in varying conditions. It should be based on recordings from real events and act as a signal simulator producing all the required feeds, which will then be input to a real OB system.

- Recorded matches are run in real time so that operators can practise operating events in an environment that closely resembles a real event.
- Used with a full OB HW setup, which simulates live operation, but not the initial calibration until calibration videos are being recorded at events.
- System bypass procedure has been very difficult to learn based on existing documentation or training, and has been learned instead by operating the system in real live operating conditions. With a simulator this can be practised very realistically in a safe environment, while the bypass procedure and documentation can also be evaluated and developed further.
- OB hardware or signal problems may be manually “simulated”. Live input signals will be fed to the OB from the simulator and all OB hardware is being used as it were a real event, so abnormal situations can be generated by disconnecting cables, using faulty HW, etc.
- Feedback for the simulator user may be presented in real time by the trainer or post-simulation, as a system output video can be recorded and compared to reference videos on acceptable output quality.
- Developers could also run recorded matches on the simulator to test new SW versions and to evaluate system performance, while learning more about “real” operating conditions in the process.
- A 1st generation signal simulator is achievable short-term with fairly low development and HW investment.
    - Develop existing camera emulator user interface and functionality so it is easy to load and run videos.
    - Create process documentation and simulator guide.
    - Purchase a BM ATEM mixer to generate CF/PGM based on the (two) recorded camera feeds and to include match graphics.

2nd generation – advanced and dynamic system simulator

The second generation simulator would be more than just a signal simulator. It would be a full system simulator that simulates also abnormal situations and problem cases, based on dynamic scenarios with varying difficulty.

- Used with full system OB HW and SW setup. Simulated scenarios from full system calibration to live operation, including supportive training tasks that help trainees reach expert operator level faster.
- Abnormal SW or HW situations (problems) triggered and simulated during scenarios.
- Live simulator feedback during simulation and an automatically generated operator performance report after simulation. Output videos will be recorded and automatically compared to reference videos on acceptable operating quality.
- Simulation controlled by an administrator (experienced operator), who sets up task scenarios, triggers problems, and provides post simulation feedback.
- Dynamic task scenarios specifically designed for the simulator
    - Utilizing an existing blueprint combining 4 C/ID model and cognitive task analysis (CTA) to create simulator task scenarios.
    - CTA is used to define steps that experienced operators perform automatically, and to incorporate supportive training to mimic experienced operator behaviour.
    - See Appendix 5 for two examples on how 4 C/ID model and CTA could be utilized to generate system simulator scenarios.
- A 2nd generation simulator is achievable long-term with fairly high development investment.
    - Develop a new SW "Simulator" component where predefined task scenarios are based on a wide video library, and abnormal situations can be triggered while feedback is automatically provided to the user during and after the simulation.
    - Start recording also (uncompressed) calibration videos and input CF/PGM at events. This way also calibrations can be simulated while actual CF/PGM feed from the event can be used at the simulator as opposed to just mixing between camera 1 and camera 2.

Improve operator and developer broadcast knowledge with a training program

This supportive training program on broadcast technology and workflow should help with on-site communication and integration problem solving with the host broadcaster. Therefore, integration should be made easier by increasing broadcast technology awareness on broadcast systems such as:

- Cameras, CCUs and vision control
- Host OBs, mixers, routers and other HW

- Signal flow, terminology and practical operation.

Training program could be arranged in co-operation with any partner broadcaster and all operators and selected key developers could take part. Training could be theoretical, but mostly practical, and the participants could also visit real events to observe how production workflow is normally handled from the broadcaster's point of view.

5.4 Theme 4 - Improve software user interface

In this section, a general strategy and some specific ideas are presented on how to gradually improve the SW UI.

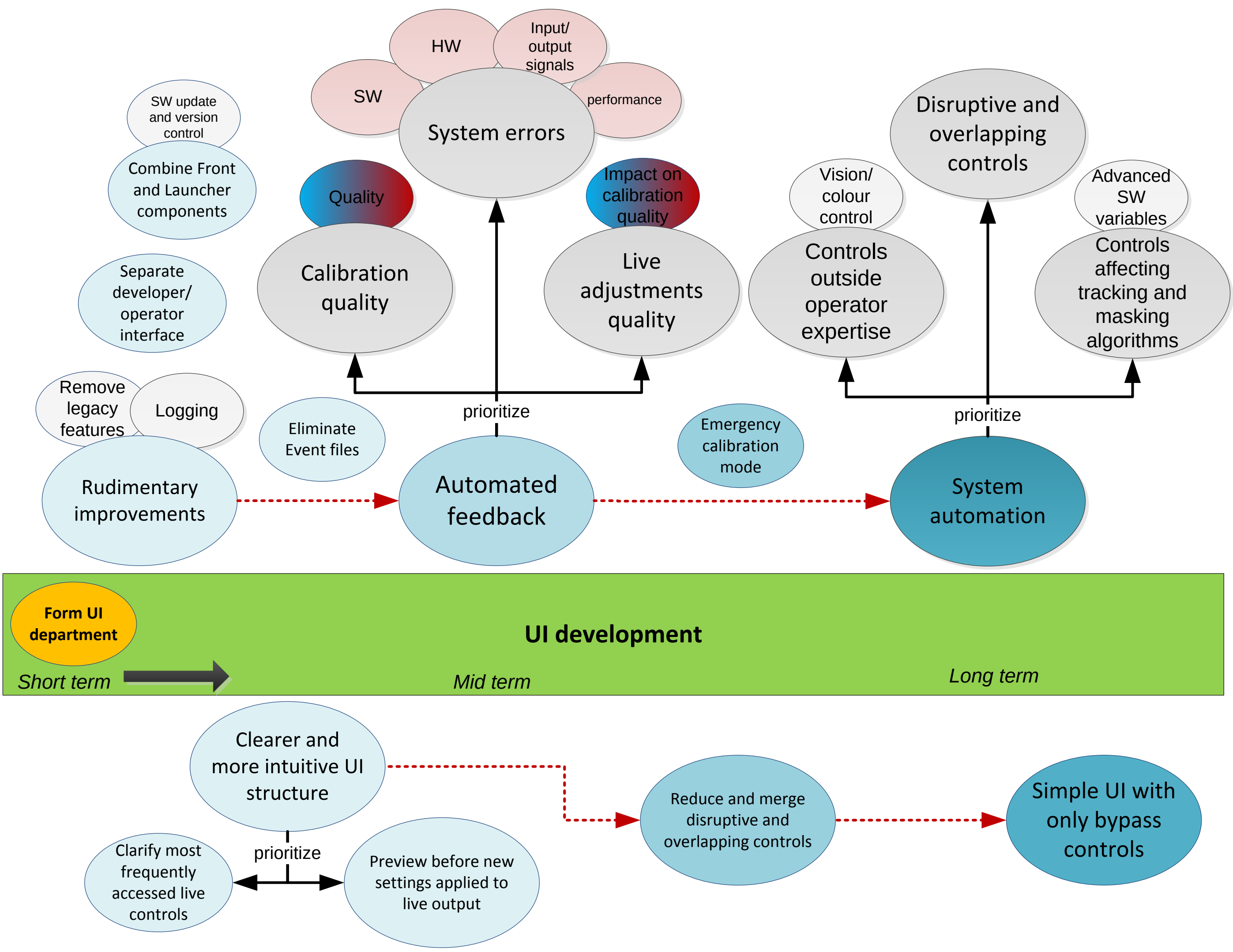

Figure 27. Action plan overview for Theme 4

Formulate formal UI “department” for R&D

At least one developer should be designated as the responsible person for all UI related design and decisions. All operational UI requests should go through this “UI department” and regular UI brainstorming sessions should be arranged with operational representatives. It may also be worthwhile seeking external consulting on UI design to get an outside view and to spare in house developer resources.

Perform rudimentary, but important improvements

Automating simple and supportive functions like logging should be done first, and all legacy features from the UI should be removed.

Make current UI structure and controls clearer and more intuitive

The general outlook and structure of an UI can always be improved. Distractive and overlapping controls should be improved first, especially those commonly used in live operating conditions.

Introduce a settings preview window

A live preview window would be very useful, as operators could always see how new settings would affect masking and tracking quality before those new settings are applied to the live system output.

Separate developer and operator interface

Remove all experimental features and algorithm level settings so that only developers could access them.

Eliminate external event files

Importing external event files to the system should be discarded. Only surveyor measurements should be input to the system directly from the surveyor or from CMS (content management system) with the ads (figure 28).

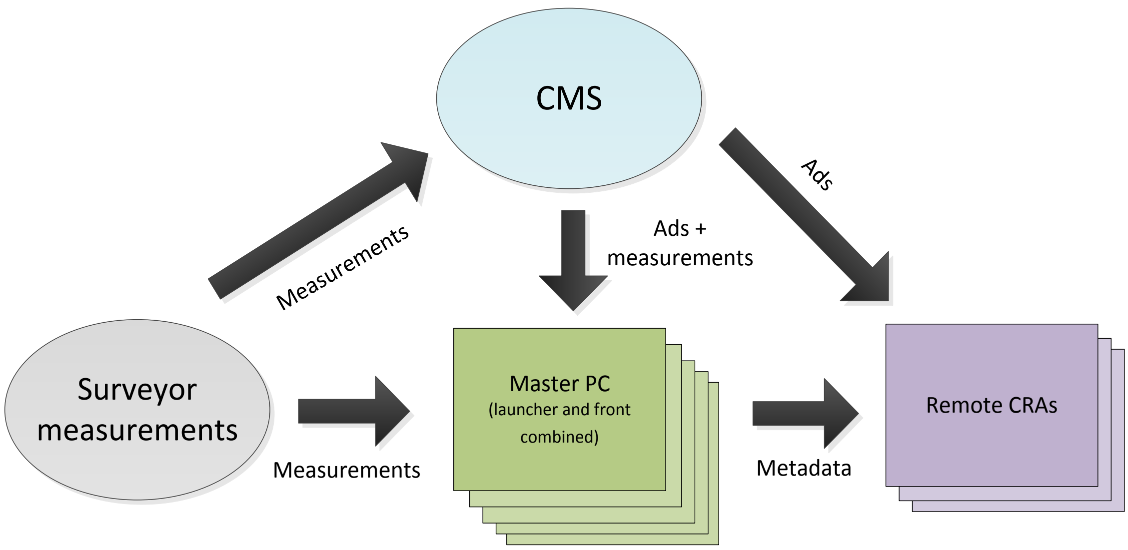

Figure 28. Only measurements should be imported to the system as opposed to event files

Eventually, also coordinate measurement will become redundant (due to new camera calibration methods), after which only the advertisement packages will be imported to the system.

Combine SW Front and Launcher components

There is no reason why these two should be separate applications, and this is most likely just a legacy feature. This is also where automatic SW group updates and version control could be incorporated.

Gradually increase automated feedback

Concentrating on calibration quality, live adjustments quality, and system errors related to SW, HW, signal or performance problems. Data mining (Theme 1) might help with feedback design and triggering, as it reveals common operator usage patterns.

Emergency calibration mode for calibration during live broadcast

If something goes wrong during a live match and a calibration step needs to be redone, it is difficult to achieve as there is no access to the live camera that is panning, tilting and zooming unexpectedly.

- Live camera feed should be recorded into a large frame buffer, where the operator could rewind back to “usable” camera shots and perform the emergency calibration instead of trying to do it with a live camera.

In the long term reduce and merge overlapping controls
Aiming at a simple UI where most controls are fully automated and running in the background.

5.5 Summary

The company should aim at moderate operator involvement in system development, albeit through a managerial filter, while more informal brainstorming and Q&A sessions should also be arranged. The questionnaire data and template from this study should be utilized in mapping out operator expectations and their skills and experience should also be charted and recognized, all of which should be managed and highlighted in system development, communication and training programs. Operational tasks that seem to lack developer recognition must be re-evaluated and better recognized by developers. Operational involvement in QA testing should also be increased and developers should be more involved at events.

The company should maintain and encourage an open atmosphere for communication and involve operators more in the event planning. It is also important to recognize and meet individual operator’s experience and corresponding information requirements. Furthermore, it should be ensured that all important information reaches operators as efficiently and as soon as possible, thus information flow must be strengthened by considering alternative communication channels and making sure all the information required for the events is stored in a centralized, cloud based system. It is also imperative that a remote support program is setup for all events and operator event reporting can also be enhanced. At the same time, external communication also needs to be improved by concentrating on broadcaster and customer communication during the pre-event planning.

A long-term training strategy needs to be formulated based on iterative and continuous training programs. Existing training programs for new, outsourced and even experienced operators should be continuous and enforced with supportive simulator –and broadcast technology training programs.

Currently, most development resources are tied to ensuring that the system first works in all possible conditions, often resulting in added complexity at the expense of usability. This is somewhat understandable at this stage, as the system needs to work first “manually” even if it means making complicated and overlapping adjustments at the UI. Only after enough data on optimal settings for different conditions is gathered, can automation be gradually increased. However, more resources should be allocated or acquired for reducing UI complexity and increasing automated feedback, as that is something that can be done in parallel with gathering data on optimal SW adjustments. Therefore, development should concentrate on UI structure in the short-term, automated feedback in the mid-term, and gradually shifting towards full system automation in the long-term.

6 Feedback on proposed action plan

In this chapter the Action Plan feedback session is described, and final propositions based on attendee feedback are discussed.

6.1 Feedback session

In a meeting with Operational -and R&D management, the research project findings (current state analysis) were first quickly summarized, after which the proposed Action Plan was presented and attendees could comment and give feedback on it.

Meeting notes on the comments that were received for each theme and action point are amended in Appendix 7, and they are analyzed next.

6.2 Final propositions based on feedback session

In the following, the received feedback is presented for each theme.

Theme 1 - Ensure system development meets operator satisfaction
Attendees agreed that it is important to first make the system work in all possible conditions even if it reduces usability. However, it was noted that usability has also improved lately. The questionnaire ratings for each task will be reviewed by both R&D and Operations, while concentrating on the most highly rated (problematic) tasks that seem to lack developer recognition (red flags). It was also noted that ratings do not take into account the individual system expertise of the operator or developer who filled in the questionnaire. Author explained that this was done on purpose, and the ratings were

treated equally because it would be difficult to emphasize and place more (or less) weight on different ratings based on the subject's experience and skill level, as it is very difficult and subjective to accurately estimate. However, it was agreed that assessing operator skill level somehow would be beneficial, especially in regard to freelance operators and monitoring their progress. This could be done by arranging operator tests and by assessment of freelancer performance at events by Team leaders.

Increasing operational involvement in system development was supported by attendees, especially in regard to QA involvement. More brainstorming meetings between operators and developers will be arranged, especially during the quiet season, and developer presence at real events should be increased so they learn more about real operating conditions. Operators should begin testing all new SW releases in a more coherent manner in closer co-operation with the QA department, while developers should make sure the release notes (information on SW updates) are better communicated to the operators. R&D will commit to hands-on training for operators for all major SW releases, while minor releases will be trained internally at operations. It was also agreed that the operations department should be better informed on planned features, as well as the planned schedule for future SW releases.

”Shadow” testing, or training in parallel with a live event, was supported by all, but it was highlighted that it is important to manage the process and to ensure that this additional work is done professionally so that it does not interfere with the live production.

Interestingly, the developers were not convinced about performing background data mining on system SW, but suggested that PC monitor outputs should be recorded, which would help especially with reproducing reported SW problems as developers could then see what operators were doing at the time of the issue. Ultimately, these recordings could be used to study and assess operator behaviour and style, and perhaps develop UI feedback when common usage patterns begin to emerge.

Theme 2 - Improve communication

It was agreed that the company is too dependent on email, and that event communication and documentation should not be distributed between different systems, but concentrated on a cloud based system, Basecamp or possibly Dropbox. This would be important not only for future events, but also when accessing plans and reports that were done for any past events.

Setting up remote technical support for operators was a somewhat controversial subject. While developers feel this would be essential in the long run, they feel the current situation is still manageable without an official support department. It was also noted that there are only a few people who would be capable of providing support for the system as a whole as key developer expertise tends to be limited to a very narrow area of the system that they are personally working on. It was concluded that remote support could be arranged so that one developer acts as the first point of contact, essentially as the middleman between operators and key developers for remote support. Alternatively, operators should be made aware which key developers they should contact on different aspects of the system. Obviously, all of this will only work if the key developers can be convinced to be on call during events that occur outside of normal office hours. This would most likely require incorporating some kind of financial -or overtime incentive.

It was concluded that nothing drastic can be done about communication problems caused by internal communication issues within the partner broadcaster organizations. What can be improved is how operators have to struggle between fulfilling broadcaster and customer requirements in terms of digital advertisement outlook. Unit Managers should manage the situation better and operators should not have to personally negotiate with the broadcaster or the customer.

The suggested FACS check has been unofficially performed at events by some operators already, but it was decided that this needs to be officially formulated into the operational workflow, i.e. documented and communicated to operators accordingly. It was also clear to all that bypass documentation and process should be enhanced, and the simulator was seen as an efficient tool to improve this.

Everyone agreed that operator event reporting could be more efficient and quick audio recordings into mobile phones will be taken into use. Furthermore, all operators should indeed take notes and meet immediately after the event to compare notes to the Team Leader’s report. Management also highlighted the need to receive a report as fast as possible after the event.

Theme 3 - Improve training programs

It was agreed that after each training program more feedback should be acquired from both trainers and trainees. A simulator training program was supported by all, especially for training new or outsourced operators. While 1st generation simulator development is fairly simple and will begin immediately, 2nd generation simulator is only for the future if at some point enough development resources can be freed from somewhere. Management also asked if the simulator could work as an online tool on any regular computer. This is possible, but would require quite a lot of development resources.

Management was also keen to launch a training program on increasing broadcast technology awareness. This could be done with partners in Holland and Spain, but only around live sports that the company is generally involved with (football).

Theme 4 - Improve SW UI

It was agreed that UI development should go through a designated person from R&D, which would increase his workload by about 10%. It was noted that performing important updates and making the UI more intuitive is already a constant and ongoing process. The settings preview window will be developed, and event files will be made redundant by near future changes to SW architecture.

Also, the CTO (Chief Technical Officer) agreed with the proposed time scale and strategy to improve the UI, where feedback is the first step to automation and, therefore, a fairly natural approach to UI development.

7 Conclusions

In this last chapter, a short summary of the Thesis workflow and findings is presented, followed by speculation on the validity and future of this research project and proposed action plan.

7.1 Summary

First the business problem, which was essentially the lack of operational scalability of the the system, was identified. It was determined that the system is difficult to operate and also to train new operators, who in turn are needed to run the system on a global scale in order to meet increasing customer demand.

Then operator workflow was defined and broken down into specific tasks that operators need to perform leading to -and during an event. Based on these tasks, a questionnaire was formed on the operational scalability of each task. Both operators and developers answered questions on the usability, training difficulty, operational risk and preferred prioritization of each task. Operators were asked to answer questions on all tasks while developers (operational and R&D) answered only tasks that they were involved in developing.

Questionnaires provided a lot of data, both numeric ratings and comments, which was analysed and summarized in the current state analysis. It was discovered that overall, operational scalability of the system is surprisingly good and both operators and developers ranked the current severity of each aspect of operational scalability in the same order. Operational risk was ranked lowest and that means system has reached a stage where operators can concentrate on operating on a routine basis and developers can concentrate on future development as opposed to continuous support for solving new problems encountered at the field. Ratings also indicated that developers are overall more critical towards the system. However, there were many individual tasks where this was not the case, and developers might need to re-evaluate their prioritization in current system development, which essentially formed Theme 1 about ensuring end-user satisfaction in all system development.

The comments provided a lot of insight into “why” operators (and developers) were concerned about the problematic nature of certain tasks. Based on this information, other re-occurring themes were identified and they revolved around issues with internal and external communication (Theme 2), training (Theme 3) and SW user interface (Theme 4).

Existing literature and research revolving around the identified themes was analysed and summarized into a conceptual framework. The main finding was that operational scalability for a system is heavily dependent on mapping out and meeting end-user capabilities and expectations in all development (Themes 1 and 4), communication (Theme 2) and other organizational support such as training programs (Theme 3), while developer satisfactions should also be taken into consideration. Therefore, all the themes emerging from the study seem to overlap considerably, both in practise and in theory. This was also a fairly re-assuring finding, as mapping out and meeting end-user expectations is very much what this study was about.

Based on ideas inspired by the questionnaire data and the theoretical research, an action plan was formulated with more or less specific suggestions and strategies on how to improve operational scalability of each identified theme. Theme 1 was mostly about ensuring moderate operator involvement in all system development and added involvement in system testing, while mapping out operator skill and experience levels. Theme 2 discussed improving communication through organizational openness and setting up remote technical support, but also about increasing information flow redundancy by concentrating on cloud based information sharing and more efficient operator event reporting. Theme 3 concentrated on providing more coherently planned, continuous and iteratively evaluated training programs to both new -and existing operators. Setting up a supportive simulator training program was emphasized and proposed specifications were discussed in detail, and a secondary training program for broadcast technology was also suggested. Finally, Theme 4 provided a proposed strategy for improving the UI, gradually moving towards full system automation through increased feedback and clarity.

The proposed action plan was then presented to Operational and R&D management and their feedback was discussed as final propositions for the action plan.

7.2 Evaluation

In this chapter, the outcome of this research project is evaluated in terms of meeting the objective set in the beginning. The reliability and validity of the research will also be assessed.

7.2.1 Objective vs. outcome

The objective of the study was to define the current operational scalability of the system, while pinpointing the core challenges and identifying ways to solve them, in order to make the technology and operational workflow more streamlined for the system operator. In practise, the output of this study was intended to serve as an information package that could then be utilized when planning and prioritizing future product development towards improved operational scalability.

The outcome of the study met this research objective very well. Current operational scalability of the system was defined in both quantitative (numerical ratings) -and qualitative (comments) form, and further analysis clearly indicated what the key challenges were, and provided concrete ideas on improving the situation in the form of an Action plan. The study also revealed which system aspects should be prioritized in future product development. This was highlighted especially from an operator's point of view, as ensuring end-user satisfaction is the basis for all successful product development, and also key to operational scalability of the system.

The questionnaire also resulted in many concrete improvement ideas and suggestions from a large group of operators and developers. However, like with most internal consulting projects, the author of this thesis is deeply involved with the research subject in his day to day work, as were all the subjects filling in the questionnaire, even to a degree where it may be difficult to remain totally objective or to come up with new and truly rejuvenating ideas. Therefore, the importance of the literary analysis (related to the identified key challenges) is especially highlighted. Consequently, this "best practises" literary analysis provided an external angle to the research project, as it helped to define and formulate the core strategies and methods that could then be built upon when incorporating concrete ideas from the current state analysis into system development in a more coherent and structured way.

In this regard, the theoretical framework became a surprisingly strong foundation for the proposed Action Plan, even to a degree where the outcome of the study somewhat exceeded the initial research objective, as it was not only defined what the current operational scalability of the system was and what the key challenges were, but also how to improve the situation in terms of more in depth strategies and methods inspired by the literary analysis.

7.2.2 Reliability and validity

Reliability and validity are all about ensuring the quality of the study, and demonstrating that both the research process and the outcome are credible and up to academic standards. Reliability refers to how well the study can be reproduced and whether it still leads to similar results and outcome. Validity, on the other hand, is about ensuring the study actually tested what it was set out to test. It refers to how objectively and accurately the research has been conducted and observations interpreted, and whether this process matched with the reality of the matter being investigated, and whether possible alternative explanations for the data have also been taken into account.

In this research project reliability and validity were improved by gathering both quantitative (ratings) -and qualitative (comments) data on different aspects of operational scalability from both operators and developers. The questionnaire targeted *all* operators who were told to answer all questions in order to make sure that the full spectrum of operator skill and experience levels would be realistically represented in the study. On the other hand, only *selected* key developers were targeted, and they were instructed to answer questions only about the things they have been personally involved in developing, resulting in more reliable developer data on questions they actually understand well.

Each subject filled in the questionnaire independently and they were asked not to discuss the questionnaire with other colleagues in order to avoid external influences and to increase the reliability of the results. For each question, the subjects were also asked to consider and rate the past and possible future (developers only) situation of the task in question. This was done to help them really think about the situation, as understanding the history (and estimating future possibilities) is the key to understanding the present, making it is easier to estimate the current situation more accurately. Therefore, past –and future ratings were not analysed in the study, nor would it have made much sense in terms of validity, as some operators were not experienced enough to provide reliable past ratings.

In order to improve the reliability of the analysis regarding the quantitative data collected (ratings), a larger sample group of operators and developers would have been ideal, but this was not possible due to the small size of the company. However, this is why quantitative data (ratings) had more of a supportive role in defining *where* the problems were, while the qualitative data (comments) was emphasized in defining *what* the problem was in each case. This helped mitigate the issue of a small sample size and the qualitative data actually supported and confirmed quantitative findings well, as it was common to see a lot of similar comments from people across both departments, especially on questions that had also received a high severity rating. These similar comments from different people also improved the validity of the research, mitigating worries about possible alternative explanations not being taken into account for the ratings.

The literary analysis on the identified key challenges (Themes) was based on numerous sources and acted as the foundation for the proposed *Action plan*. As the findings (themes) from the current state analysis were merged with the literary framework, it became clear that these identified themes were very much intertwined and overlapping also in existing theory, which is a fairly reassuring finding in terms of the validity of the study.

The author has been working for years on the operational scalability of the system and this level of expertise is good for validity, but the downside is that it may make it more difficult to remain objective and unbiased. Author's personal experience is strongly reflected on the foundations of the study: breaking down the operational workflow into specific tasks that the questionnaire template was built upon, and defining "Operational scalability" as a concept by categorizing it into usability, training difficulty, operational risk and preferred prioritization, was all based purely on the author's personal experience and expertise.

However, retaining objectivity was emphasized in the data analysis stage, which was very transparent and thorough, resulting in a fairly extensive appendix 6 where operator and developer ratings and comments were not only analysed in great detail, but also compared. This comparison indicated that, overall, both parties ranked current severity of each operational aspect exactly in the same order, developers being a bit more critical towards each aspect as would be expected of them as they are essentially evaluating the results of their own handiwork. These are also reassuring findings for the validity of the study.

While the subjects' questionnaire ratings and comments were treated as objectively as possible, all subjects were also treated equally and not evaluated based on the individual's experience or position. It would have been possible to place more weight on the ratings and comments of the more experienced operators and developers, but this would have hindered objectivity and with an already limited sample size, resulted in an unrealistic representation of the current operational scalability of the system. Finally, as mentioned before, the literary analysis provided an external angle on the research, and direct feedback on the results and proposed *Action plan* from key developers, managers and experts also helped improve the validity of the process.

Since the data collection was based on a questionnaire template that is archived together with the filled in questionnaires (raw data), this study is easily reproducible, which of course enhances reliability. Therefore, in the future this study will be reproduced annually and similar results are expected to be obtained, but with visible improvements on all areas of operational scalability as the proposed *Action plan* is implemented in actual product development. Ultimately, the validity of this research project will thus be tested in practise, when it is seen whether the ideas and strategies presented in the proposed *Action plan* have in fact been valid and whether operational scalability has indeed improved as expected.

7.3 Next steps

In the action plan, general strategies and methods were presented together with concrete ideas and suggestions for improving the situation. Although not all ideas may turn out to be practical or feasible to implement, most of them should be realistic and worthwhile to apply in development of the system, which should improve the operational scalability of the system.

Therefore, the Action plan will be taken into account when planning for future development, and it should have a clear impact on future development strategy, especially since the lack of operational scalability is a well-recognized problem within the company. Ideas that require less development resources, or ideas that are considered critical, are likely to be immediately applied into current development.

Below, some concrete steps are presented on how the Action plan should be applied in practise within the company.

- Teams consisting of key developers and managers are formed for each Theme.
- The author is responsible for coordinating the teams and assigning them tasks based on the ideas and suggestions in the Action plan that were approved in the feedback session.
- Main responsibilities for the team working on Theme 1:
    - Prioritizing and pushing development for the most highly rated (problematic) tasks that seem to lack developer recognition (red flags).
    - Incorporating continuous operator skill assessment through operator tests and team leader –and operator peer review.
    - Increasing operational involvement in R&D development through coordinated meetings, joint testing -and training programs.
- Main responsibilities for the team working on Theme 2:

  - Incorporate cloud based system for all event communication and operational documentation.
  - Set up a process for remote support in terms of key developers being on call and as first points of contact for operators.
  - Implement centralized remote access and control over the Internet.
  - Clarify Unit Managers responsibilities at events
  - Clarify operator documentation, especially regarding live bypass.
  - Improve operator event reporting guidelines and procedure so that all operators take part.
- Main responsibilities for the team working on Theme 3:
  - Build an iterative training program for operators based on continuous feedback and skill assessment.
  - Set-up a system simulator program that can be used for both training and testing purposes.
  - Set-up a training program with selected broadcast partners on increasing operator broadcast technology awareness.
  - Create a training manual utilizing operator workflow and detailed task analysis found in appendix 6
- Main responsibilities for the team working on Theme 4:
  - Ensure UI development keeps up with the rapid SW development.
  - Based on the proposed strategy for UI development, arrange open brainstorming sessions on UI development with operators.
  - Ensure all UI development requests go through the designated UI person at R&D.
- As the different themes often overlap considerably, the teams will also meet regularly in order to continuously assess how ideas from the Action plan are implemented.
- The questionnaire template from the study will be updated and reproduced annually by the author. This is done in order to track how well development meets operator satisfaction, but also to continuously gather new development ideas from operators without a managerial filter and to better understand operator skill and experience level –which was highlighted with all of the themes.

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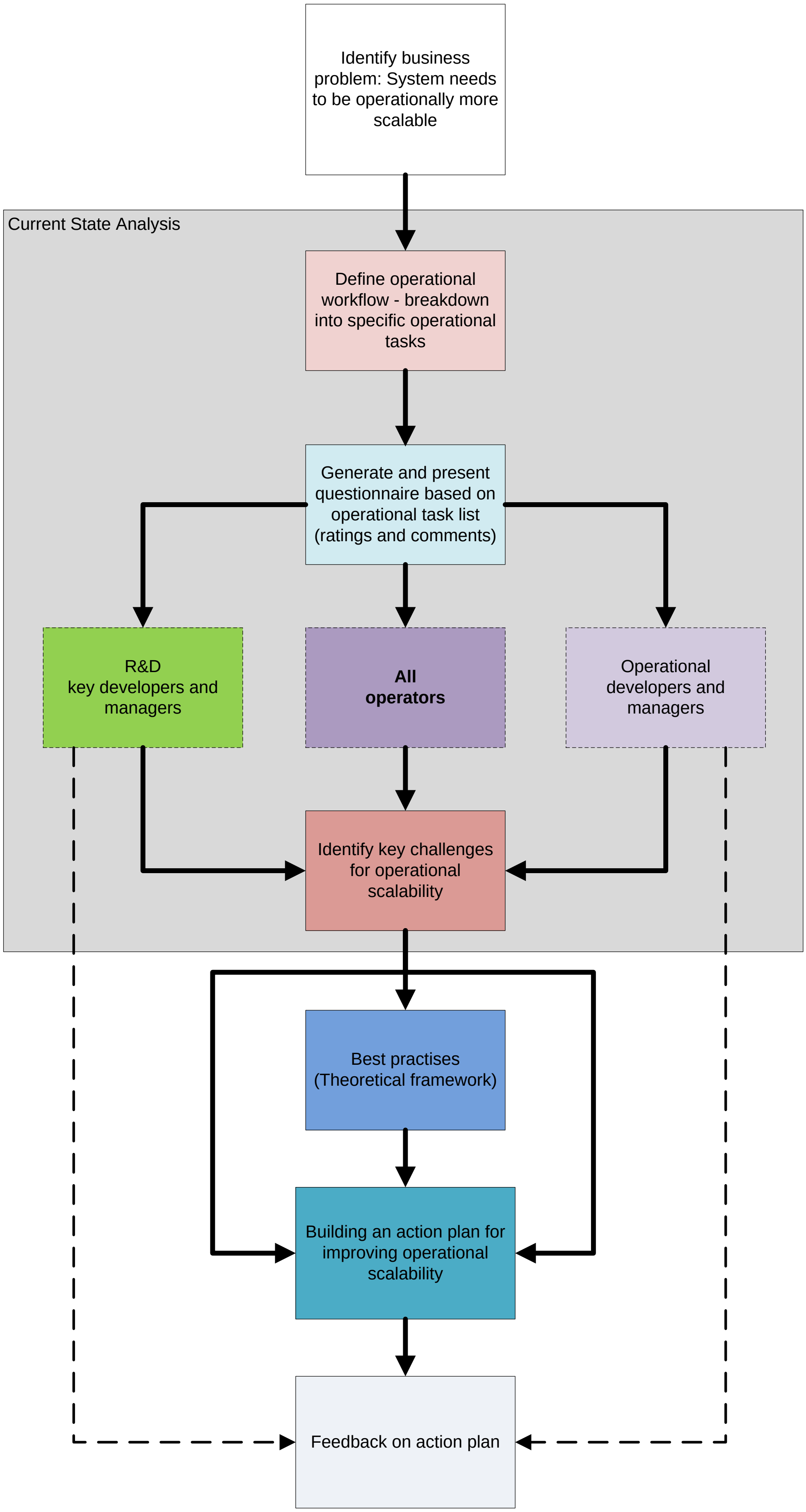
Appendix 1 – Research plan



Appendix 2 – Operational task list and identified themes

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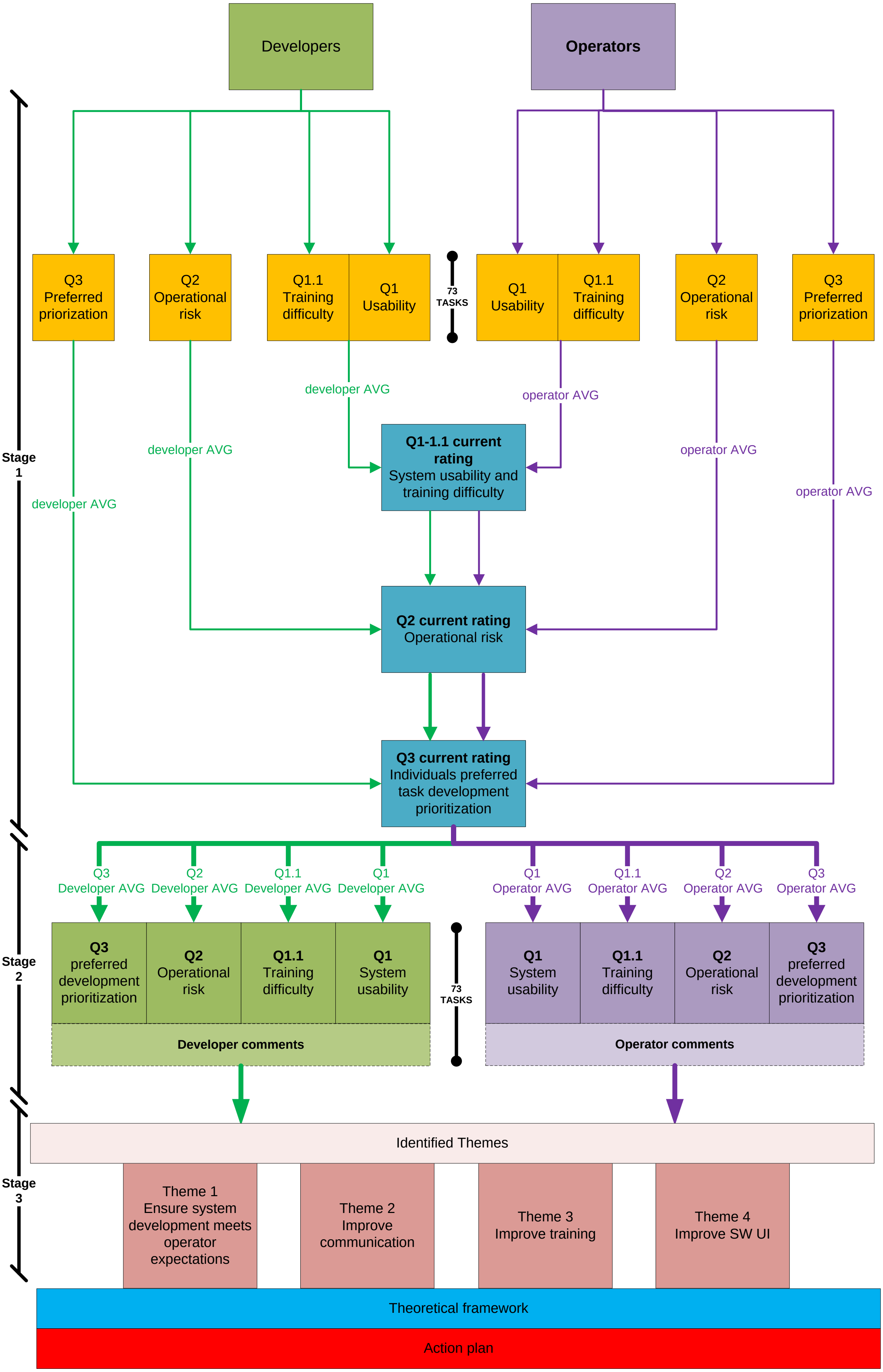
Appendix 3 – Data analysis workflow



Appendix 4 – Questionnaire ratings summary

See “ops now” for operator average ratings and “dev now” for developer average ratings for each question and a total task average on all questions (operational scalability). Symbol ∆X indicates difference between operator and developer ratings on each questions.

Task	ops now Q1 AVG	dev now Q1 AVG	ΔQ1	ops now Q1.1 AVG	dev now Q1.1 AVG	ΔQ1.1	ops now Q2 AVG	dev now Q2 AVG	ΔQ2	ops now Q3 AVG	dev now Q3 AVG	ΔQ3	ops now O-AVG	dev now D-AVG	FLAG -->
1	3,1	2,3	-0,8				3,3	2,0	-1,3	3,4	3,5	0,1	**3,3**	2,6	
2	2,1	1,8	-0,3				2,4	2,0	-0,4	2,3	3,4	1,1	**2,3**	2,4	
3	2,1	1,8	-0,3				2,3	1,8	-0,5	2,4	4,3	1,9	**2,3**	2,6	
4	2,0	2,2	0,2	2,0	2,0	0,0	2,2	2,0	-0,2	2,3	2,4	0,1	**2,1**	2,2	
5	1,8	1,5	-0,3				1,8	1,8	0,0	2,3	3,0	0,7	**2,0**	2,1	
6															
6.1	3,0	2,3	-0,7				2,9	2,0	-0,9	3,0	3,7	0,7	**3,0**	2,6	
6.2	2,3	1,3	-1,0	2,4	1,0	-1,4	2,1	2,0	-0,1	2,6	3,0	0,4	**2,4**	1,8	
6.3	2,0	2,2	0,2	2,1	2,2	0,1	2,1	2,2	0,1	2,9	3,2	0,3	**2,3**	2,5	
6.4	2,0	3,0	1,0	2,3	2,8	0,5	1,4	2,5	1,1	1,7	3,3	1,6	**1,9**	2,9	
6.5	2,1	3,3	1,2	2,3	3,0	0,7	1,3	2,0	0,7	1,9	3,0	1,1	**1,9**	2,8	
6.6	2,3	2,8	0,5	2,7	3,0	0,3	2,0	2,8	0,8	3,3	1,7	-1,6	**2,6**	2,5	
6.7	1,7	2,0	0,3	2,0	2,0	0,0	1,7	1,6	-0,1	2,1	1,8	-0,3	**1,9**	1,9	
6.8	1,9	2,0	0,1	1,7	2,0	0,3	1,9	2,0	0,1	1,6	2,0	0,4	**1,8**	2,0	
6.9	3,1	2,3	-0,8				2,9	2,7	-0,2	3,6	3,0	-0,6	**3,2**	2,7	
6.10	1,7	2,2	0,5	2,4	2,8	0,4	2,1	1,8	-0,3	2,6	1,8	-0,8	**2,2**	2,2	
6.11	2,0	2,8	0,8	2,3	3,0	0,7	1,9	2,0	0,1	2,3	2,2	-0,1	**2,1**	2,5	
7															
7.1	2,0	2,0	0,0	2,7	1,5	-1,2	2,7	2,0	-0,7	3,2	2,0	-1,2	**2,6**	1,9	
7.2	2,0	3,0	1,0				1,7	3,5	1,8	2,2	3,0	0,8	**1,9**	3,2	
7.3	1,7	1,7	0,0				1,8	1,7	-0,1	2,3	3,5	1,2	**1,9**	2,3	
8.1	1,7	2,0	0,3	1,7	2,0	0,3	2,0	2,0	0,0	1,8	3,0	1,2	**1,8**	2,3	
8.2	1,3	2,5	1,2	1,8	2,8	1,0	1,5	1,5	0,0	2,2	2,0	-0,2	**1,7**	2,2	
8.3	1,8	2,5	0,7	2,8	3,0	0,2	1,7	2,0	0,3	1,8	2,8	1,0	**2,0**	2,6	
8.4	1,0			1,2			1,2			1,3			**1,2**		
9															
9.1	1,3	1,9	0,6	1,3	2,0	0,7	1,5	1,3	-0,2	1,5	2,3	0,8	**1,4**	1,9	
9.2	1,3	1,8	0,5	1,7	1,8	0,1	1,3	2,0	0,7	1,8	2,8	1,0	**1,5**	2,1	
9.3	1,5	2,0	0,5	1,5	2,0	0,5	1,3	1,7	0,4	1,2	2,3	1,1	**1,4**	2,0	
9.4	1,8	3,4	1,6	2,0	3,4	1,4	1,8	3,2	1,4	2,0	3,5	1,5	**1,9**	3,4	
9.5	2,5	3,0	0,5	2,5	2,8	0,3	2,5	2,0	-0,5	2,5	2,6	0,1	**2,5**	2,6	
10															
10.1	1,4	1,7	0,3	1,7	2,4	0,7	1,4	1,9	0,5	1,6	2,0	0,4	**1,5**	2,0	
10.2	2,1	2,6	0,5	2,4	3,0	0,6	2,1	3,1	1,0	2,4	3,1	0,7	**2,3**	3,0	
10.3	2,3	2,5	0,2	2,2	3,5	1,3	2,0	2,1	0,1	1,5	2,3	0,8	**2,0**	2,6	
10.4	1,9	2,6	0,7	2,1	2,4	0,3	2,4	2,4	0,0	2,6	3,4	0,8	**2,3**	2,7	
10.5	2,4	2,7	0,3	2,6	2,3	-0,3	3,0	2,8	-0,2	3,1	3,4	0,3	**2,8**	2,8	
10.6	2,1	1,8	-0,3	2,3	1,8	-0,5	2,1	1,5	-0,6	2,0	2,0	0,0	**2,1**	1,8	
10.7	1,9	2,1	0,2	1,9	2,0	0,1	1,6	1,6	0,0	2,1	2,5	0,4	**1,9**	2,1	
10.8	2,0	2,5	0,5	2,6	3,2	0,6	2,0	2,7	0,7	3,0	3,8	0,8	**2,4**	3,0	
10.9	2,0	2,8	0,8	2,6	3,0	0,4	2,3	2,7	0,4	3,0	3,7	0,7	**2,5**	3,0	
10.10	2,3	3,0	0,7	2,9	3,0	0,1	2,0	2,3	0,3	3,1	3,6	0,5	**2,6**	3,0	
11															
11.1	2,5	3,3	0,8	2,8	3,7	0,9	3,2	3,2	0,0	3,5	4,0	0,5	**3,0**	3,5	
11.2	1,7	2,6	0,9	2,4	3,1	0,7	2,0	2,4	0,4	3,6	2,6	-1,0	**2,4**	2,7	
11.3	2,9	3,4	0,5	2,7	3,6	0,9	2,7	2,9	0,2	3,9	4,0	0,1	**3,0**	3,5	
11.4	2,6	3,6	1,0	3,3	4,1	0,8	3,0	4,0	1,0	4,0	4,9	0,9	**3,2**	4,2	
11.5	3,0	4,0	1,0	3,0	4,1	1,1	2,9	3,6	0,7	3,7	4,4	0,7	**3,1**	4,0	
11.6	2,1	2,4	0,3	2,3	2,6	0,3	2,4	2,9	0,5	3,1	3,1	0,0	**2,5**	2,8	
11.7	2,6	3,3	0,7	2,7	3,5	0,8	2,6	2,3	-0,3	3,7	3,3	-0,4	**2,9**	3,1	

	Q1 - System usability			Q1.1 - System training difficulty			Q2 - Operational risk			Q3 - Preferred prioritization			Q AVG - operational scalability		
	operators now	developers now	ΔQ1	operators now	developers now	ΔQ1.1	operators now	developers now	ΔQ2	operators now	developers now	ΔQ3	Operator AVG	Developer AVG	ΔAVG
12	1,9	1,8	-0,1	2,1	2,0	-0,1	1,6	1,6	0,0	2,0	2,2	0,2	**1,9**	1,9	
13	2,1	2,0	-0,1	2,4	2,1	-0,3	1,7	1,7	0,0	2,4	2,3	-0,1	**2,2**	2,0	
14	2,2	2,0	-0,2	2,2	2,2	0,0	1,8	2,0	0,2	2,2	2,2	0,0	**2,1**	2,1	
15	2,2	3,8	1,6	2,3	3,6	1,3	2,2	3,2	1,0	2,5	4,0	1,5	**2,3**	3,7	
16															
16.1	2,3	2,3	0,0	2,7	2,8	0,1	2,8	2,3	-0,5	3,0	3,0	0,0	**2,7**	2,6	
16.2	2,2	2,2	0,0	2,5	2,2	-0,3	2,2	2,2	0,0	2,7	2,2	-0,5	**2,4**	2,2	
16.3	1,7	2,2	0,5	1,8	2,4	0,6	1,7	2,0	0,3	1,7	2,6	0,9	**1,7**	2,3	
17	2,1	2,4	0,3	3,1	2,4	-0,7	2,9	2,9	0,0	4,0	3,0	-1,0	**3,0**	2,7	
18															
18.1	2,6	2,6	0,0	2,9	2,4	-0,5	2,7	2,3	-0,4	3,0	2,4	-0,6	**2,8**	2,4	
18.2	2,4	3,7	1,3	3,0	3,9	0,9	2,7	3,0	0,3	3,7	4,4	0,7	**3,0**	3,7	
18.3	2,6	3,3	0,7	3,0	2,8	-0,2	2,1	2,8	0,7	3,3	3,4	0,1	**2,8**	3,1	
18.4	2,7	3,7	1,0	2,7	3,7	1,0	2,4	2,9	0,5	3,3	4,0	0,7	**2,8**	3,6	
18.5	2,6	2,7	0,1	2,7	2,3	-0,4	2,6	2,7	0,1	3,4	3,1	-0,3	**2,8**	2,7	
18.6	2,4	3,5	1,1	3,0	3,9	0,9	2,3	3,0	0,7	3,6	4,3	0,7	**2,8**	3,7	
18.7	2,8	3,6	0,8	3,3	3,7	0,4	2,6	2,9	0,3	3,4	3,7	0,3	**3,0**	3,5	
19	1,7	1,7	0,0	1,8	1,8	0,0	1,5	1,8	0,3	1,8	2,0	0,2	**1,7**	1,8	
20	1,7	1,9	0,2	2,2	1,9	-0,3	2,0	1,9	-0,1	2,0	2,3	0,3	**2,0**	2,0	
21	2,2	1,8	-0,4	2,0	2,0	0,0	2,0	1,8	-0,2	2,7	2,3	-0,4	**2,2**	2,0	
22															
22.1	2,4	2,3	-0,1				2,6	2,3	-0,3	2,7	2,3	-0,4	**2,6**	2,3	
22.2	1,7	2,0	0,3				1,8	1,7	-0,1	2,7	2,3	-0,4	**2,1**	2,0	
22.3	1,4	1,7	0,3				1,4	1,7	0,3	2,1	2,7	0,6	**1,7**	2,0	
22.4	1,6	2,0	0,4				1,6	1,5	-0,1	2,1	1,0	-1,1	**1,8**	1,5	
22.5	2,3	2,3	0,0				2,4	2,3	-0,1	3,1	3,0	-0,1	**2,6**	2,5	
22.6	1,3	2,0	0,7				1,2	1,9	0,7	1,3	2,3	1,0	**1,3**	2,0	
22.7	1,5	1,3	-0,2				1,3	1,3	0,0	1,7	2,3	0,6	**1,5**	1,7	
22.8	1,7	2,6	0,9				1,7	2,3	0,6	2,2	2,5	0,3	**1,8**	2,5	
22.9	1,5	1,3	-0,2				1,5	1,7	0,2	1,5	2,7	1,2	**1,5**	1,9	
22.10	1,5	2,0	0,5				1,3	1,6	0,3	1,8	2,3	0,5	**1,6**	2,0	
AVG	**2,1**	**2,4**	**0,3**	**2,4**	**2,7**	**0,3**	**2,1**	**2,2**	**0,1**	**2,5**	**2,9**	**0,4**	**2,2**	**2,5**	**0,3**

Appendix 5 – 4 C/ID & CTA blueprint for simulator scenarios

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Appendix 6 – Detailed task analysis

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Appendix 7 – Feedback meeting notes

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